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[OFFICIAL NOTICE.]

American Gas Light Association.

OFFICE AMERICAN GAS LIGHT ASSOCIATION,
142 CHAMBERS STREET, NEW YORK.

To the Members of the Association:

The Ninth Annual Meeting of the American Gas Light Association will be held in Boston, on Wednesday, Oct. 19th, and continue for three days.

Members of the Association are earnestly requested to prepare papers upon the many topics of general interest, to be read at that meeting. The Secretary counts upon the active co-operation of the members in his efforts to render the meeting of marked value.

WM. HENRY WHITE,
Secretary.

New England Association of Gas Engineers.

The next Semi-Annual Meeting of the members of the Association, with their ladies and friends, will be on the 17th and 18th days of August, 1881, at the "Hotel Pines," Point of Pines, a programme of which is hereto annexed.

Members may invite, in addition to the ladies, any gentlemen of their acquaintance.

Board and lodging at the hotel, at the rate of $3.50 per day for each guest.

The Committee earnestly request all those receiving this circular to notify the Secretary, on or before the fifteenth day of August, inst., whether or not they propose to attend this meeting, and whether they wish rooms engaged.

For information as to trains, etc., please examine the accompanying circular.

GEO. B. NEAL,
Secretary.

JOHN ANDREW,
J. H. ROLLINS,
O. E. CUSHING,
GEO. B. NEAL,
Committee of Arrangements.

PROGRAMME.

Wednesday, August 17th.—12 M.—Business meeting of the Association; 2 P.M., lunch; 3 P.M., inspection of the new and complete coal gas works on the premises; rowing, fishing, etc.; 6 P.M., banquet. Evening—Promenade with ladies, music, fireworks, etc.

Thursday, August 18th.—8 to 9 A.M., breakfast; 10 A.M., excursion by steamboat; 3 P.M., dinner.

APPARATUS FOR BURNING GAS.

Great improvements in apparatus for burning gas have been made within a few years, and the margin for still further advances is so great, and so much attention is being given to the subject, that there is every promise that the future will bring developments that are at present only to be imagined and wished for.

There can be no doubt that there will be a large increase in the consumption of gas, not only for lighting, but also in the comparatively undeveloped fields of heating and cooking, and motive power.

The introduction of powerful electric lights to the public has induced and cultivated a demand for what a few years ago would have been considered extravagant illumination. Experience in gas lighting has shown that, where the public has become accustomed to the enjoyment of a great amount of light, it will not be satisfied to return to the old ways of a feeble illumination such as was given out by oil lamps or candles. There is every reason to believe that electricity is only an agent for largely increasing the consumption of gas, as, by the probable future improvement in burners for consuming economically large quantities of gas, it is likely, on account of their economy, convenience, reliability and pleasantness, gas lights will, but in exceptional locations, displace the large electric lights. There should, however, be every effort made to inform and show the public what can be done with gas where an extravagant lighting is desired, as there is a large demand for this kind of lighting now, and, in most cases, it is carried on quite regardless of cost.

This policy of supplying the consumers with what they want has not yet been carried out here to any extent, whereas in Paris and other large European cities the introduction of large gas lights has been very considerable, and has largely increased the gas consumption. The reason, for what might be regarded as a neglect of an important duty, may be, to a great extent, the difficulty of obtaining, and having properly erected, the necessary apparatus. There is no doubt if parties here were prepared to furnish and erect improved apparatus of all kinds for lighting they would immediately find a large and profitable business, and receive every encouragement from the gas companies.

This state of affairs does not exist as regards apparatus for cooking and heating by gas, as our manufacturers have given much attention to this question, and have produced, and are able to supply, articles as good as can be obtained elsewhere. Some exceptions may perhaps be made as to price which, in some cases, seems high, and prevents extended adoption. It is true that there is great room for improvement in our cooking and heating apparatus, but it is a subject for congratulation that much attention is being given to the matter.

With regard to the manufacture, supply, and introduction of gas engines, it seems that there is much yet to be desired. It is quite well accepted that where a moderate amount of or intermittent power is required, the gas engine is both reliable and economical, and there is reason to believe that future improvements will render it economical even where comparatively large power is required. Complaints have been made that the prices charged for gas engines are too great and considerably prevents their introduction. Not only so, but prompt delivery is a question of great importance in these days, and a delay often prevents a sale. Moreover, there is a great demand for small power, say under one horse power, and it does not seem that any one here is prepared to furnish motors of this class.

The recent formation in England of three companies, with large capital, and with capable and well-known men as directors, for the express purpose of producing, on a large scale, and introducing all improved apparatus for using gas, including burners, fittings, stoves and engines, is an evidence of faith in the future of the gas industry. These companies will, if well managed, undoubtedly succeed; and it would seem that there is an opportunity and a demand for a like enterprise here.

THE GERMAN ASSOCIATION OF GAS AND WATER WORKS MANAGERS.

The annual meeting of the above Association was held at Frankfort-on-the-Main, on the 21st, 22d, and 23d of June, Herr Simon Schiele presiding. An account of the proceedings is given in the *Journal fur Gasbeleuchtung*, of July 15th.

This Association, the oldest of the many now in active existence in different portions of the world, celebrated its twenty-first birthday by a meeting that was well-attended and full of interest. This society, and its members, have done much for the gas industry of the world, perhaps in no direction to so great an extent as in the investigation of the principles, and in constructing and working generator furnaces. This is to-day one of the most important subjects for consideration in the construction or reconstruction of gas works, and nowhere else has so much been done regarding it as in Germany.

This question was not particularly considered at the meeting, but it has been suggested that a new committee be appointed to again consider and investigate what has been recently done in this direction. Such action would doubtless result in information of a reliable and valuable kind, which would be of great service to those who have already fully determined that retorts must, for the sake of economy, be heated by a gas furnace, accompanied by a good regenerator. Many want to know which is the furnace and regenerator giving, all things considered, the best results.

Cooking and heating by gas was considered; and a committee was appointed to investigate and report on this important subject. The organization of the society was considered, and, after an excursion, the meeting adjourned.

THE NORTH BRITISH ASSOCIATION OF GAS MANAGERS.

The twentieth annual meeting of this Association was held at Glasgow, on July 21st, under the presidency of Mr. James McGilchrist, who delivered an address in which he expressed the fullest confidence in the future of gas lighting, considered the so-called competition of electricity with gas as absurd, and called attention to heating and cooking by gas, and to improvements in the erection of purifiers.

Papers were read on "Gas Service Pipes," "Regenerative Gas Firing for Retorts," "Modified System of Carbonizing," "A Year's Experience with Young's Patent Washer-Scrubber," "Two New Processes of Gas Purification Based on the Direct Utilization of its Impurities in the Production of Commercial Salts," and "Heating by Gas."

The meeting is said to have been most successful.

New Gas Works in Cincinnati.

NEW WORKS TO BE ERECTED AT A COST OF ABOUT $400,000.

The Cincinnati Gas Light and Coke Company have purchased the old Sportsman's Hall in the East End and the lot on which it stands—400 feet front by 600 feet deep—for the purpose of erecting new works to be used for supplying the eastern and northeastern, as well as other parts of the city in case of fire or other accident to the old works at the foot of Rose street, which would cause the gas to be shut off from the lower works.

A *Commercial* reporter having heard of the rumor of the purchase called upon General Hickenlooper, the president of the company, yesterday, and was informed by him that it was a fact that the company had made the purchase, and contemplated putting up works with a capacity of two millions and a half of cubic feet. The company are now at work on the drawings, and will put up the foundations for the new works some time next summer. The design of the company is to construct works of the exact capacity of the lot, without the necessity of extending the works at a future period.

It is intended to put up Ross' steam stoking machinery, which it is supposed will save the interest on the investment, amounting to between $50,000 and $60,000 a year.

General Hickenlooper says the investment will amount to between $350,000 and $400,000, and by the erection of the new works, the company will be able to supply Walnut Hills, Avondale, Columbia and Pendleton with gas at a much less outlay than by extending the mains from the old works to those points. The new location is about on the line of McMillan street, and is much nearer Walnut Hills than any other point on the river than they could have selected.

The company is well prepared to make the improvement, as the stock is not only worth $1.70, and hardly obtainable at that figure, but there is a large surplus on hand, which can be used to advantage in building new works and occupying additional territory.

In view of the recent great fire in the bottoms, the company feels the imperative necessity of building works remote from any great manufacturing establishments, which are liable to take fire at any moment and cause not only great loss to themselves, but also the destruction of property by which the city would be deprived of gas for an indefinite period.—*Ex.*

The New Chesapeake Bay Lighthouse.

What is regarded as one of the finest lighthouses in the world is being erected in Chesapeake Bay, off Cape Henry. From base to top it measures 155 feet, with a diameter at the base of 30 feet and at the top of 16 feet. There are six stories, above which are a service room, watch room, lantern room, and finally the roof. Its total weight is 1,700,000 pounds, 7,000 lbs. of bolts alone being required to put it together. The exterior, which is octagonal in shape, is constructed of cast iron, while the cylindrical interior is of sheet iron.

The castings of the base and first story are two inches in thickness, and the sheet iron lining 3-8ths inch. The staircase, which has iron sill steps, goes around the cylinder instead of up a shaft as in the lighthouse now in existence. The "light room" is a circular steel frame 12 feet in diameter and nine feet high.

The glass to be used is now being manufactured in France, and a light of great power will be adopted.

Every story is solidly bolted together by heavy cast iron floor plates 1¼ inches thick, while the points and facings are finely planed, four planers having been kept running night and day for the last eighteen months. So closely are the plates fastened together that from the outside each story looks like a solid piece of iron. The base and windows are elaborately ornamented with castings, while a handsome iron railing surrounds the watch room. Many of the bolts are one and three-quarter inches in diameter at one end, and seven-eighths of an inch at the other.—*Sci. Am.*

Profits of Cheap Gas.

The Springfield (Ill.) *Journal* says that a few months ago the Cincinnati gas light company reduced its rate to $1.60 per thousand feet. The effect has been to largely increase the consumption of gas, and at the same time increase the measure of profit to the manufacturers. They are so well pleased with the experiment that it is predicted they will soon make a further voluntary reduction to $1.25. Of course there is a minimum rate below which gas cannot be manufactured at a profit, but until that is reached it would appear to be the part of wisdom and sound business policy to make the price so low that everybody can afford to use it freely.

Extension of the Electric Gas Lighting System in Salem, Mass.

It is almost a year since the Thermo and Electric Gas Lighting Company of Boston began its work in the city of Salem, Mass., where it is regularly lighting and extinguishing all the street lights in the largest ward. This work has been so satisfactorily performed that the authorities have concluded to extend the system throughout the city, as is best shown by the following extract from the Salem *Post*, of July 13 :

"At their last meeting the Board of Aldermen voted, without a dissenting voice, to extend the Thermo and Electric Gas Lighting Company's method of street lighting throughout the city. This is a wise measure and so far as we have heard gives unqualified satisfaction to our citizens.

"It is one of those public measures—unfortunately too rare—which lightens the burden on the long-suffering public treasury, for the city is not called upon for the expenditure of a single dollar except in payment for services rendered. Since September last the Thermo company has operated the lamps in Ward Two in a manner eminently satisfactory to the committees on lamps and lighting of both last and the present year.

"Although there are but 420 street gas lamps it is shown by the experience of the past eight months that the saving will amount to $1400 to $1600 annually, and this too after the company's yearly royalty is paid. The electric lighting station has been permanently established in the city building on Bridge street, at the foot of Howard street, where the process of lighting can be witnessed any evening."

In an extended description of the system, published in the Salem *Gazette* —that paper says ;

"Ward Two, being the most scattered, so far as the arrangement of lamps is concerned, was assigned the gas lighting company to make their demonstration in, and here they began work early in September last. * * * In a short time the wires were all buried under the pavements, and, after meeting and overcoming some difficulties, all the street lamps in the assigned territory, covering nearly seven miles, were regularly lighted and extinguished.

"Up to the present time everything has gone smoothly and well, although one of the worst of our usually severe winters has been passed through. This remarkable freedom from accident, under peculiarly trying circumstances, is due not alone to the exceeding simplicity of the apparatus, but also to the perfect security of underground lines from the destructive influences of storms, fires and like dangers incident to overhead wires.

"The apparatus used by this company has already been fully described in the columns of the *Gazette*, and it need only be repeated that the plant consists of three essential parts ; a dynamo machine or mechanical generator of electricity, driven from any convenient source of power, underground lines of insulated wire, and a peculiar fixture at each burner. This fixture is so constructed that the heat of the burning gas is stored up, as power, in any amount according to the size of the expansion bar, in such a manner as to perform the alternate functions of opening and closing the gas keys, while the only office the electric current has to perform is to heat an igniting loop of platinum wire and operate a let-off mechanism, which allows the gas key to alternately be thrown open or in the opposite direction, by the accumulated power from the heat of the burning gas, as the occasion requires.

"As the system is now arranged, a Lewiston water motor furnishes the power for the dynamo machine, and is operated at an expense of 16 cents for a lighting and extinguishment. An Otto gas engine has also been set up at the side of the water-motor, and it is the intention to test the relative economy of the two means of acquiring power.

"By the use of the electric system a large saving for the taxpayers will be effected, for under the present practice the men begin lighting the lamps an hour and a-half before they can complete their rounds, over an hour of which time is saved in that part of the city, where the electric system is used. In other words, every night that the lamps are lighted those operated by electricity are ignited an hour later and extinguished an hour earlier than those controlled by hand. As the city is charged for four feet of gas per hour for each lamp, and as there are 420 street gas lamps in the city, the saving per day, or year, is a matter of very simple mathematics. An equal, if not greater, saving, although that is directly proportionate to the number of lamps, will be effected in the matter of labor. Before the company began work the city employed six men to light and extinguish the lamps, and one of these has since been displaced. These men are each paid $1 a night, or $6 for the entire number, so when the electric method is extended throughout the city, there will be a saving of $6 per night for 280 nights a year making a gross economy of $1680 in labor. From this, however, should be deducted, say $100 for water and incidentals, besides the wages of an operator, unless that office is performed by the present superintendent of lamps who could for a slight addition to his present salary assume the additional duty. Admitting that $680 per year were allowed for labor and power, there would then be left a balance of $1000 in the labor account, and add to this $1500, which Supt. Stillman estimates will be saved in gas, the city would gain $2500 a year, which would soon wipe out the cost of the electric system.

"These estimates are modest ones and are based on the experience of a long and severe winter, while one large element of gain is scarcely considered. That element is the saving in gas which can, and will, be attained on such nights as those when the moon suddenly shows out through a clouded sky. It often happens that, at the time for lighting, the moon is obscured by dense clouds the lamps are lighted, and, expecting a stormy night, the men disperse to their homes ; but a few hours later, while the lighters are unconscious in sleep, the moon breaks through, and, till the regular hour for extinguishing arrives, the gas is needlessly burning.

"In such an event by the electric system all the lamps could be instantly extinguished, and a great consumption of gas avoided. Again, it would be possible to light the whole, or any section, of the city in a case of a fire or any other unforseen emergency.

"Since their system has been in full operation the Thermo company, as it is familiarly called, has had but one difficulty to contend with ; the obstruction of the gas pipes by frost and accumulation of a substance known as naphthaline. Both of these accumulations are well known to gas men and have always been a fruitful source of annoyance. They dim, extinguish, or prevent the lighting of lamps by any method ; but in their absence the electric system never fails to work. To meet this difficulty the company combines with its mechanical devices a manual safeguard in the form of a personal inspection, by the lamp cleaners, who, with any system, must be employed. Immediately after lighting and extinguishing, the cleaner goes to a few central points in his district, and from a rapid glance down the diverging streets sees that all the lamps are burning, or out, as the case may be, and if he discovers any trouble, remedies it at once. At present one man inspects over six miles of streets in less than 15 minutes and at no extra expense."

As the wires are in use for lighting and extinguishing the gas but a few seconds in the morning and evening they can, and are, utilized at Salem for fire alarm purposes. The company has devised and patented methods by which fire alarms and telephonic systems are connected with their lighting method, and in such a manner that neither can interfere with the other.

The headquarters of the Thermo and Electric Gas Lighting Company are at 14 Exchange Place, Boston, Mass. The company is in readiness to introduce its system of lighting and extinguishing in any city or town in the country.—*Adv.*

New Hydrocarbon Furnace.

The *Scientific Press* contains the following description of a new form of hydrocarbon furnace :

"It is nothing new in hydrocarbon furnaces to employ a series of pockets filled with a mass of refractory material saturated with the oil, which pockets alternate with air chambers which receive air at the bottom and discharge it at the top, where it combines with the gases evolved to effect combustion.

"An Eastern inventor, however, has got up a hydrocarbon furnace having the bottom of its combustion chambers made with a series of longitudinal pockets containing asbestos or analogous absorbent material, with perforated oil pipes imbedded therein, and with alternating air chambers arising between said pockets and communicating below with the portion of the furnace corresponding to the ash-pit. The said air chambers being perforated at the top and surmounted by inclined hoods or sheds which deflect the currents of air down upon the surface of the saturated asbestos.

"The advantage of these hoods is said to be that having their sides or wings extending obliquely down into the asbestos pockets, and deflecting the air currents down upon the surface of the asbestos, they contribute to the intimate mingling of the gases and produce a more active combustion. These hoods, also, by covering the perforations on the top of the air chambers prevent them from becoming stopped up. A successful hydrocarbon furnace will be a valuable thing."

Velocity of Light in Quartz.

In investigations upon refraction, Kohlrausch found nearly uniform values in different pieces of any given substance, while Quincke subsequently asserted that there were great variations in the refractive relations of quartz, which appear to be somewhat dependent upon the age of the surface from which the total reflection was observed.

He states that this difference reached two units of the second decimal place in some cases. Hallock has carefully examined a number of specimens and the greatest difference that he found was less than one unit of the third place. This included the uncertainty of observation, which was equivalent to at least two or three units of the fourth place.—*Wiedem. Ann.*

[A Graduating Thesis Read before the Stevens Institute of Technology.]

Gas Engines.

By Albert Spies, M.E.

(Continued from page 60.)

As to the actual expense of a gas engine as compared with that of a steam engine, the following estimates may prove interesting. They are taken from a paper read before the North British Association of Gas Managers.

The gas engine under consideration was an Otto silent engine, erected at the works of the Edinburgh and Leith Gas Company. It was rated at 3½ nominal horse power, and was employed to drive various machines, such as a Root's blower for three smiths' fires, a large screw-cutting lathe, a screwing machine, a drilling machine, two grindstones, a circular saw, and two small lathes. The amount of power required varied considerably at times, notwithstanding which, however, the speed of the engine was pretty uniform. The attendance required was slight; the lubrication was effected by an ingenious self-acting arrangement, and the only labor worthy of note was the examination of the slide valves once a week to see if the passages to the cylinder were unobstructed. A water tank was in connection with the engine for cooling purposes, and it was noticed that the amount of cooling water needed after the first filling was almost zero, the temperature not rising much, because, the engine resting during meal and night hours, allowed the water to cool. If, however, the engine were running continuously, as would be the case in driving an exhauster, a small stream of water would be necessary, and this would have to be taken into account in estimating the expense of the engine for such a purpose.

The cost of the engine for the year from May 15, 1879, to May 15, 1880, working 57 hours per week was—

Gas for engine and slide lights—99,000 cubic feet, at 4s. 2d. per 1,000	£20	12	6
16 gallons sperm oil for lubrication	2	16	0
Attendance, estimated at one hour per day, at 4d. per hour	5	4	0
Total expense	£28	12	6

The first cost of the engine and water cistern complete was £170. Taking the annual wear and tear at 7½ per cent., this will give £11 18s. Depreciation at the same rate gives £11 18s.; giving a total of £23 16s. The working expenses being £28 12s. 6d., this gives for the total expense for the year £52 8s. 6d. The working expenses differ, of course, with different prices of gas, the above estimated price being, however, a fair average. The amount of power derived from this expenditure was on an average about 2 horse power. The use of the several machines was intermittent, but it took about 1½ horse power to drive those constantly in use, and an addition of about ½ horse power on an average for those that were used occasionally. The gas consumption was about 17 cubic feet of gas per indicated horse power per hour, excepting when working with a full load, in which case the gas consumption was much greater.

The cost of a steam engine and boiler of 3½ horse power, and equal in respect of workmanship to the Otto gas engine, would be about £110; and the usual allowance for wear and tear and for depreciation would be 10 per cent. per annum for both engine and boiler of this size. The working expenses would be—

Fuel, at 8s. per week for 52 weeks	£20	16	0
Wages of attendant, at 12s. per week	31	4	0
Oil for lubrication, same as gas engine	2	16	0
Water supply for the boiler	2	10	0
Total working expenses	£57	6	0
Add for wear and tear 10 per cent. on cost	£11	0	0
" depreciation 10 " "	11	0	0
Total charge for one year	£79	6	0

The cost of the fuel will be more or less according to the locality, but the above is a pretty fair estimate. We find, then, the general results to be—

Working expenses of a gas engine	£28	12
" " steam engine	57	6

And taking wear and tear and depreciation into account, the final expenses would be—

Expenses for gas engine	£52	8	6
Expenses for steam engine	79	6	0

This, then, speaks greatly in favor of the gas engine, the expenses of the steam engine being underestimated rather than overestimated.

In using a gas engine it should be observed that the gas should be taken from a large main, not less than 4 inches in diameter; this precaution being necessary to prevent the oscillation of the lights. The gas pressure should be about .7 of one inch of water.

THE LENOIR GAS ENGINE.

This was one of the first gas engines worthy of special attention, and which came into an extended use, about 500 of them being at work in France. The engine resembles a horizontal steam engine very much, its principal part being a hollow cylinder closed at both ends, and provided with an air-tight piston. When the flywheel is turned, the piston, moving forward, creates a partial vacuum behind it, and into this space the explosive mixture is admitted and there exploded.

Fig. 1 shows the inlet valve of the engine; the gas supply pipe is connected with the chamber *E*, which is bolted to the main cylinder, the distributing valve sliding between these two. Now, as soon as the piston moves forward, the gas passes through the ports N into the semi-circular channel which covers them, and through this into a space in which it is thoroughly mixed with air, thence passing into the cylinder to perform its work. On the other side of the cylinder is a separate valve for allowing the products of combustion to escape.

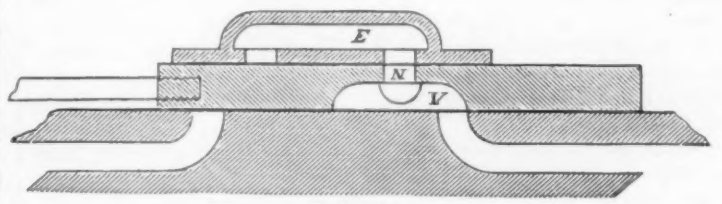

Fig. 1.

The dimensions used in the following description are for a 2-horse power engine.

The valve *V* is made of cast iron, and is about 1¼ inches thick; the back plate *E* is provided with four set screws, to tighten the valve to the cylinder faces when they become worn, and is held in place by studs at the corners, thus preventing the valve from being lifted off by the force of the explosion. The cylinder of the engine is 8¼ in. in diameter, and has a stroke of 28 in. It is bolted to a cast iron bedplate 7 ft. 2 in. long, 1 ft. 3 in. wide, and 7 in. deep, carrying near one end the plummer blocks for the crank shaft.

It should here be remarked that the cylinder is completely surrounded by a water jacket, in order to carry off the superfluous heat of the explosion. The cylinder covers are also supplied with water spaces, which are connected with the water spaces around the cylinder by means of pipes. After flowing through all the water spaces, the cooling water, which is then quite warm, is removed by a pipe, and may be used for heating and other purposes. The pipes mentioned are about 1¼ in. in diameter. The piston rod is 1¼ in. in diameter, and its outer end is cottered into a cross-head which embraces a pair of round guide bars 1¼ in. in diameter; these are placed at a distance apart of 6 in. from center to center. The cross-head is also furnished with brass bushes fitting these guide bars. The connecting rod is made with strap ends, and is 37 in. long from center to center; the crank bearings are about 2 in. in diameter and 3 in. long, the cheeks of the crank being 2¼ in. wide and 2 in. thick. The crank shaft bearings are 11 in. apart from center to center, and the plummer blocks are furnished with set screws, by means of which the brasses can be shifted horizontally, the distance of the crank shaft from the cylinder being thus rendered adjustable.

The eccentrics working the valves are fixed on the crank outside the plummer blocks, the straps being made of brass. The flywheel is very heavy, and is 7 ft. 4 in. in diameter. A governor, moved by the engine, regulates the gas supply. In the French engines of this type there is a weak point arising from the excessively high temperatures at which the gases escape through the exhaust port. This difficulty is overcome in the American engines by allowing a small stream of water to trickle through the port.

To ignite the explosive charges an electric spark is employed, and the mechanism for ignition may be described as follows:

At one end of the crank shaft is placed the distributor, which regulates the transmission of the electric sparks; it consists of a short wooden arm secured to an iron ring which is fixed on the crank shaft by means of a set screw. This arm carries a piece of brass, the inner end of which bears against a brass ring fixed on an annular piece of wood, supported by a bracket from the engine frame. To this annular piece of wood there are also fixed at its outer edge two pieces of brass, forming about a quarter of a ring (C and D in fig. 2); upon these pieces the brass which is fixed to the wooden arm bears during a portion of a revolution. The inner ring B and the two outer portions of a ring are each furnished with a thumb-screw for the attachment of the wires leading to the induction coil machine and to the igniters. One igniter is inserted at each end of the cylinder, and it

consists of a brass plug through which a porcelain cylinder passes; through this cylinder are led two copper wires. One of these wires is connected with the brass plug and the other is furnished with a thumb-screw at its outer end. At that end of the porcelain tube which is within the cylinder of the engine, the two wires are bent down so that they are about 1-16th in. apart, and thus readily admit the passing of an electric spark. Sometimes these ends of the wires are made of platinum, but it has been found that copper is a cheaper and an equally efficient substitute. The igniters are each connected by means of insulated wires with one of the portions of a

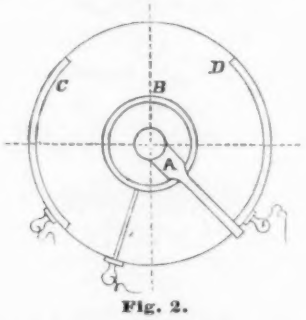

Fig. 2.

ring forming part of the distributor, the igniter inserted at that end of the cylinder next the crank shaft being connected with the nearest segment of ring, whilst the other segment is connected with the other igniter.

The necessary electricity is furnished by a carbon battery of two cells, the wires of the battery being connected with the primary coil of the ordinary induction coil machine, wires from the secondary coil of which are connected one with the earth and the other with the inner brass ring of the distributor.

To start the engine a few turns must be given to the flywheel by hand. Its gas consumption is about 70 cubic feet per horse power per hour. The total weight of the engine, including the flywheel is 23¼ cwt., and the space needed for it is 10 ft. by 10 ft. 3 in.

These engines have been worked at a piston speed of 400 ft. per minute, but they are not intended to run at more than half that speed. One of them was reported to have made 2,276,218 revolutions without the slightest derangement of any part. Great heat in its cylinder does not seem to be destructive to the surfaces, for in one of these engines there was used but 1 quart of oil during one month. In one instance a friction dynamometer was applied to a Lenoir engine whose cylinder had a diameter of 4¾ in., and a length of stroke of 8¾ in.; the length of the lever of the dynamometer was 4 ft., and the applied weight was 7 pounds. Number of revolutions, 185; and the dynamometer was found to record 16,280 foot-pounds per minute, this being equivalent to nearly one-half horse power. In France engines of the Lenoir type of more than one-half horse power cannot be used economically, on account of the high price of gas.

Theory of the Lenoir Engine.

The degree of heating of the gases in a gas engine depends evidently upon the relative proportions of gas and atmospheric air contained in the explosive mixture, and also upon the composition of the gas. This consists of olefiant gas, light carbureted hydrogen, hydrogen, carbonic oxide, and nitrogen, in the following proportions (for average illuminating gas nearly):

Hydrogen	21
Light carbureted hydrogen	56
Olefiant gas	7
Carbonic oxide	11
Nitrogen	5
Total	100

Now, it is known that one volume of olefiant gas unites with three volumes of oxygen, yielding two of carbonic acid and two of water vapor. Similarly one volume of light carbureted hydrogen unites with two of oxygen, giving one volumme of carbonic acid and two of water vapor. One volume of hydrogen combines with one-half volume of oxygen, producing one volume of water vapor. Finally, one volume of carbonic oxide unites with one-half volume of oxygen, the union resulting in one volume of carbonic acid.

The result of the combustion of 100 volumes of coal gas will then be as follows:

Olefiant gas	7	+	21	O =	14	CO_2	+ 14	H_2O
Light carbureted hydrogen	56	+	112	O =	56	CO_2	+ 112	H_2O
Hydrogen	12	+	10½	O =			21	H_2O
Nitrogen	5			=	5			
Carbonic oxide	11	+	5½	O =	11	CO_2		
	100		149		86		147	
Nitrogen with oxygen in air			560		560			
			809				793	

Therefore 809 volumes of the original gases yield 793 volumes of products of combustion.

One cubic meter of average gas will weigh about .535 kilogrammes = S_0 at standard pressure and temperature, and the same volume of air under similar conditions weighs 1.225 kilogrammes = s_0; the density of the gas therefore is

$$d_0 = \frac{S_0}{s_0} = \frac{.535}{1.225} = .4367$$

One kilogramme of this gas gives by complete combustion about 10430 heat units (calories) = K_1. Consequently one cubic meter gives

$$K = S_0 K_1 = .535 \times 10430 = 5580 \text{ heat units.}$$

Since one kilogramme of gas requires for complete combustion $L_1 = 14.5$ kilogrammes of air about, therefore one cubic meter of gas requires an air volume—

$$L = \frac{L_1 S_0}{s_0} = 14.5 \times \frac{.535}{1.225} = 6.3 \text{ cubic meter.}$$

If we now mix 1 cubic meter of gas with x cubic meters of air, the weight of 1 cubic meter of the mixture evidently is

$$s = \frac{1.225x + .535}{x + 1} \text{ kilogrammes.}$$

and the density of the mixture is

$$d = \frac{s}{s_0} = \frac{1.225x + .535}{1.225\,(x + 1)} = \frac{x + .4367}{x + 1}$$

After complete combustion the density of the resulting products of combustion is

$$D = \frac{x + .48}{x + .83}$$

the density having increased; hence the increase of density is in the ratio

$$\frac{D}{d} = \frac{(x + .48)\,(x + 1)}{(x + .83)\,(x + .4367)} = \frac{x^2 + 1.48x + .48}{x^2 + 1.2667x + .3625}$$

Furthermore, the specific heats for constant volume and constant pressure are given by the following formulæ:

$$\text{Specific heat for constant volume, } Cv = \frac{.1684x + .286}{x + .48}$$

$$\text{Specific heat for const. pressure, } Cp = \frac{.2375x + .343}{x + .48}$$

x being, as before mentioned, the proportion of air in the mixture of gas and air.

Experiments have shown that during combustion about ¼ to ⅓ of the heat produced by combustion is conducted away by the cooling water, and consequently only ⅔ to ¾ of the total heat is utilized; hence, if it is assumed that only the Xth part of 1 cubic meter of gas furnishes the requisite heat of expansion, this heat is

$$X\,K \text{ heat units (calories).}$$

This amount of heat is distributed through $(x + 1)$ cubic meters of mixture, which weigh $(x + 1)s$ kilogrammes. Therefore each kilogramme contains

$$X\,K \div (x + 1)s \text{ heat units.}$$

Denoting the original absolute temperature by T_0 and the temperature after explosion by T_1, we have

$$T_1 - T_0 = \frac{1}{Cv} \times \frac{X\,K}{(x + 1)s}$$

If we also designate the original pressure corresponding to T_0 by p_0, and the pressure after explosion by p_1, then, if there were no increase of density, we should have

$$\frac{p_1}{p_0} = \frac{T_1}{T_0}$$

But we know that the ratio of increase of density is represented by the ratio $D \div d$, hence we have

$$\frac{D}{d}\,\frac{p_1}{p_0} = \frac{T_1}{T_0}$$

Or, putting $D_1 = D \div d$, we have

$$D_1 \frac{p_1}{p_0} = \frac{T_1}{T_0}$$

from which equation we obtain the value

$$p_1 = \frac{T_1 p_0}{T_0 D_1}$$

After having exploded the mixture, expansion would take place adiabatically, if the cooling water did not abstract heat, and consequently the law of variation of pressure and volume is expressed by the equation

$$p_m v^n = p_1 m v_1^n$$

We now wish to determine the external work, or the delivery of the engine. Let Q be the number of disappearing heat units during expansion, and let L be the delivery required; also let $1 \div A = 424$ meter kilogrammes = Joule's equivalent; then

$$L = \frac{1}{A} Q = \frac{Cv}{A} (T_1 - T) = \frac{Cv}{A} (273 + t_1) - \frac{Cv}{A} (273 + t)$$

t_1 and t being the initial and final temperatures respectively (temperatures before and after expansion). Dividing by $(273 + t_1)$, we obtain

$$\frac{L}{273 + t_1} = \frac{Cv}{A} - \frac{Cv\,(273 + t)}{A\,(273 + t_1)}$$

The factor $\frac{273 + t}{273 + t_1}$ is equal to $p^{(k-1) \div k} \div p_1^{(k-1) \div k}$, k being equal to $\frac{Cp}{Cv}$; we also know that $R(273 + t_1)$ equals $v_1 p_1$,

R being the external work done by 1 kilogramme of gas by expanding when it is heated from 0° to 1°, its value being 29.272 meter kilogrammes when air is the expanding fluid. Then, if 10334 kilogrammes is the pressure of the air on one square meter,

$$\frac{p_0 v_0}{273 + t_1} = \frac{10334}{1.29318 \times 273} = \frac{10334}{353.03814} = 29.272 \text{ (for air.)}$$

1.29318 being the weight of one cubic meter of air. Also,

$$R(273 + t_1) = v_1 p_1 \;.\;\therefore\; (273 + t_1) = \frac{v_1 p_1}{R}$$

Substituting this value of $(273 + t_1)$ in the equation

$$\frac{L}{273 + t_1} = \frac{Cv}{A} - \frac{Cv\,(273 + t)}{A\,(273 + t_1)}$$

we obtain

$$\frac{LR}{v_1 p_1} = \frac{Cv}{A} - \frac{Cv}{A}(p^{(k-1) \div k} \div p_1^{(k-1) \div k})$$

Therefore

$$L = \frac{Cv}{AR} v\, p_1 - \frac{Cv}{AR} v_1 p_1 (p^{(k-1) \div k} \div p_1^{(k-1) \div k})$$

Since, however,

$$\frac{273 + t}{273 + t_1} = v_1^{.41} \div v^{.41}$$

we have

$$L = \frac{Cv}{AR} v_1 p_1 - \frac{Cv}{AR} v_1 p_1 (v_1^{.41} \div v^{.41})$$

Cp and Cv being the specific heats for constant pressure and volume respectively, we have Cp — Cv = amount of heat corresponding to outer work = R = 29.272 meter kilogrammes.

We also have the following proportion:

$$Cp - Cv : 1 :: R : \frac{1}{A} \;.\;\therefore\; \frac{Cv}{AR} = \frac{1}{k - 1}$$

k being equal to Cp ÷ Cv. Substituting this value of Cv ÷ AR in the equation

$$L = \frac{Cv}{AR} v_1 p_1 - \frac{Cv}{AR} v_1 p_1 (v_1^{.41} \div v^{.41})$$

we obtain

$$L = \frac{v_1 p_1}{k - 1} - \frac{v_1 p_1}{k - 1} (v_1^{k-1} \div v^{k-1})$$

the exponent .41 in the upper equation being correct only for the expansion of air. Placing $k = n \div m$, and making the proper substitution, we get the following equation:

$$L = \frac{m}{n - m} v_1 p_1 - \frac{m}{n - m} v_1 p_1 (v_1^{(n-m)+m} \div v^{(n-m)+m})$$

v_1 being the volume of the mixture before and v its volume after expansion. This value of L gives the delivery only during expansion, not taking into account the work of the back pressure, which latter is obtained as follows: Let F be the area of the piston in square meters, s equal stroke of the piston, and let $e_1 s$ be that portion of the stroke passed over during the admission of the gas, e_1 being a fraction. We then have

$$\frac{v_1}{v} = \frac{Fe_1 s}{Fs} = e_1$$

the value of e_1 being termed the "degree of fill." If in our last equation we substitute for $v_1 \div v$ its equivalent value e_1, we have

$$L = \frac{m}{n - m} p_1 Fe_1 s - \frac{m}{n - m} pFe_1 s (e_1)^{(n-m)+m} = Fsmp_1 \frac{e_1 - e_1^{n+m}}{n - m}$$

Now, the work of back pressure of the air is

$$Fp_0(s - e_1 s) = Fp_0 s(1 - e)_1$$

p_0 being the atmospheric pressure; subtracting this from the value of L, we have

$$Fsmp_1 \frac{e_1 - e_1^{n+m}}{n - m} - Fsp_0(1 - e_1) = \text{effective delivery per stroke.}$$

If the engine makes u revolutions per minute, then the effective delivery per second is

$$Ls = \frac{u}{30} Fsmp_1 \frac{e_1 - e_1^{n+m}}{n - m} - \frac{u}{30} Fsp_0(1 - e_1) \text{ meter kilos.}$$

This, then, gives us the delivery for perfect efficiency. Denoting the efficiency by y, we obtain for the actual delivery

$$Ls = y\frac{u}{30} Fsmp_1 \frac{e_1 - e_1^{n+m}}{n - m} - y\frac{u}{30} Fsp_0(1 - e_1) \text{ meter kilos.}$$

Dividing this by 75, we obtain the horse power developed.

The gas consumption per revolution is given by the proportion

$$x + 1 : 1 :: 2Fe_1 s : z \;.\;\therefore\; z = \frac{2Fes}{x + 1}$$

$$\text{Consumption per second} = \frac{uFe_1 s}{30(x+1}$$

$$\text{Consumption per horse power per second is } \frac{uFe_1 s}{30(x + 1) \times HP}$$

$$\text{Hence the consumption per horse power per hour is } \frac{120uFe_1 s}{(x + 1) \times HP}$$

Grashof found that these equations gave results agreeing very closely with experimental results, provided m and n were placed equal to 1 and 2 respectively. This would give for the law of variation of pressures and volumes the very simple equation

$$pv^2 = p_1 v_1^2$$

If we place

$$\frac{y}{30} mp_1 \frac{e_1 - e_1^{n+m}}{n - m} - \frac{y}{30} p_0(1 - e_1)$$

equal to l, and find values for l, for different values of e_1, together with the relative amounts of gas consumed per horse power per hour, it will be observed that there is a certain value for e_1 which will yield a maximum ratio of delivery to gas consumption, and which will prove of maximum economy. Thus, suppose the mixture to consist of 13 volumes of air and 1 volume of gas; assume the efficiency to be about .55, and then introduce different values for e_1, and we will find the following values for l and for the gas consumption:

Values of e_1	.40	.45	.50	.55	.60
Values of l	112.4	139.1	151.1	158.1	160.2
Values for gas consumption	2.12	2.08	2.13	2.24	2.41

From this it will be observed that the economy is greatest when e_1 is equal to about .50; according to which the gas supply to the cylinder should be cut off at about one-half of the stroke, and then be exploded.

As before stated, the cylinder has a water jacket to prevent overheating, and there now remains to be calculated the quantity of cooling water that is necessary. We have previously assumed that a certain portion of heat only was used for the expansion of the working fluid, as much heat as is contained in $(1 - X)$ cubic meters being abstracted. This heat equals

$$(1 - X)K \text{ heat units.}$$

Heat is now abstracted from the products of combustion during expansion, and to find this heat we must determine the temperature at the end of expansion, which is done as follows:

If we denote the pressure at the end of expansion by p_1, then according to the law of change of pressure and volume $pv^2 = p_1 v_1^2$, we find

$$p = \frac{p_1 v_1^2}{v^2} = p_1 e_1^2$$

Now, in place of $p_1v_1v_1^{n+m}$ or pv^{n+m} we can put

$$\frac{p_1v_1v_1^{n+m}}{v_1} = p_1v_1v_1^{(n+m)-1}$$

And similarly

$$pv^{n+m} = \frac{pvv^{n+m}}{v} = pvv^{(n+m)-1}$$

Hence,

$$p_1v_1v_1^{(n+m)-1} = pvv^{(n+m)-1}$$

Since, however, $p_1v_1 = RT_1$ and $pv = RT$, we have by substitution

$$RT_1v_1^{(n+m)-1} = RTv^{(n+m)-1}$$

Therefore

$$T_1v_1^{(n+m)-1} = Tv^{(n+m)-1} \therefore \frac{T}{T_1} = v_1^{(n-m)+m} \div v^{(n-m)+m} = e_1$$

From this we can find T, the temperature corresponding to the pressure p_1, its value being

$$T = T_1 \times v_1^{(n-m)+m} \div v^{(n-m)+m} = T_1e_1$$

The heat, then, which is abstracted during expansion is found as follows: In the expression

$$L = \frac{m}{n-m}p_1v_1 - \frac{m}{n-m}p_1v_1(v_1^{(n-m)+m} \div v^{(n-m)+m})$$

the portion $v_1^{(n-m)+m} \div v^{(n-m)+m}$ we know to be equal to $T \div T_1$, and $p_1v_1 = RT_1$; hence we have

$$L = \frac{m}{n-m}RT_1 - \frac{m}{n-m}RT = \frac{m}{n-m}R(T_1 - T)$$

Also, since

$$R = \frac{Cv(k-1)}{A}$$

$$L = \frac{m}{n-m} \times \frac{Cv(k-1)}{A}(T_1 - T)$$

The change of inner work is

$$U - U_1 = \frac{Cv}{A}(T - T_1)$$

And if Q is the amount of heat equivalent to these two works, we have

$$\frac{Q}{A} = U - U_1 + L, \quad \text{or} \quad Q = A(U - U_1) + AL$$

and by inserting the values of $(U - U_1)$ and L, we have

$$Q = Cv(T - T_1) + \frac{m}{n-m}Cv(k-1)(T_1 - T)$$

This may be written

$$Q = Cv(T_1 - T) - \frac{m}{n-m}Cv(k-1)(T_1 - T)$$

or, $Q = \frac{mk-n}{m-n}Cv(T_1 - T)$ = heat abstracted for 1 kilogramme of the mixture. Now, one cubic meter of the mixture weighs $1.225x + .535$ kilogrammes; therefore the heat abstracted during expansion from each cubic meter of the mixture is $Q(1.225x + .535)$ heat units.

After the exhaust valve is opened the pressure falls rapidly from p to the atmospheric pressure p_o, and that portion of the heat disappears which helped in increasing the rectilinear motion of the gas molecules. The products of combustion then escape under the constant pressure p_o, and, it may be assumed, at a temperature T_2, and we must then abstract $(1.225x + .535)Cp(T - T_2)$ heat units, giving for the total heat abstracted from 1 cubic meter of the mixture

$(1 - X)K + Q(1.225x + .535) + (1.225x + .535)Cp(T - T_2)$ heat units.

If, therefore, the engine under consideration consumes B cubic meters per hour, the heat abstracted will be

$$[(1 - X)K + Q(1.225x + .535) + (1.225x + .535)Cp(T - T_2)]\,B$$

If the cooling water has been heated through C degrees, then W, the weight of water which must circulate per hour around the cylinder, is given by the formula

$$C \times W = [(1 - X)K + Q(1.225x + .535) + (1.225x + .535)Cp(T - T_2)]B$$
$$\therefore W = (1 - X)K + Q(1.225x + .535) + (1.225x + .535)Cp(T - T_2)]B \div C.$$

This weight is, however, somewhat too great, as the heat which disappears suddenly when the exhaust valve is opened is disregarded.

The time required for the explosion of the gaseous mixture was found to be about 1-27th of one second, and consequently the increase of pressure is immediate. Since the piston, however, can yield but gradually, there is at the time of explosion a shock which not only not contributes to the motion of the piston, but which is highly injurious to the moving parts. An amount of heat corresponding to this shock is transferred to the cylinder walls and to the piston.

This loss of power by impact is one of the main objections to the Lenoir engine, and later inventors have introduced various methods to overcome this difficulty. Pierre Hugon, in his engine, introduced with the gas supply a quantity of water, which in evaporating absorbed considerable heat, and thus tended to prevent the excessive elevation of temperature which occurs in the Lenoir engine. The expansive force is necessarily somewhat diminished by this, but the moving parts suffer less, and the engine is more durable, requiring much less repair.

In this engine the ignition of the explosive charges is effected by small gas jets, which are introduced into the working cylinder at the proper moment.

Figure 3 shows two indicator diagrams of the Lenoir engines. Diagram A was obtained from an engine having a cylinder of 8¼ in. diameter and a length of stroke of 16½ in. Since the explosion did not occur immediately after the gas supply was cut off, the tension of the gases fell below the atmospheric pressure, as shown in the figure. The dotted line represents the

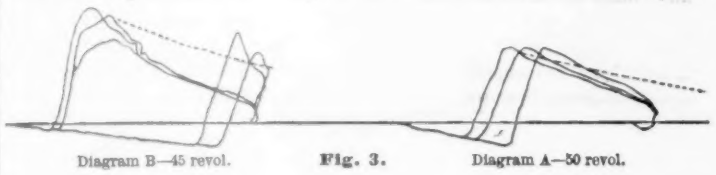

Diagram B—45 revol. **Fig. 3.** Diagram A—50 revol.

theoretical expansion line, taking into account the loss of heat and the consequent fall of pressure due to the work done. Diagram B was obtained when the electrical points were wet, and, owing to the uncertain passage of sparks, the explosions were irregular.

Hugon's as well as Lenoir's engine, although now almost dropped out of sight, was at its time used in quite a number of establishments, and not without practical results. In France, and especially in Paris, Lenoir's engine was used in the building of houses for raising building materials, sawing, printing, pumping, etc. Owing, however, to later inventions, which were without many of its defects, it gradually fell behind, leaving its place to be filled by one of the finest inventions of the century—namely, the atmospheric gas engine.

[To be continued.]

Compressed Bituminous Pavement.

The value of bitumen as a leading ingredient in forming a perfect pavement has long been recognized, although its use has hitherto generally been attended by several drawbacks. It has, however, been used—compounded with various materials—only in the monolithic or sheet form, or moulded without pressure into blocks. Experience has demonstrated that, for the streets of commercial cities, this form of pavement is not sufficiently compact to resist the action of the elements, or abrasion from traffic for any reasonable length of time. It is too smooth for draft purposes and dangerous, especially under the influence of slight moisture. Efforts have frequently been made to remedy these objections, and to render this class of pavement sufficiently compact, by the use of heavy steam street rollers, &c., but without practical result. The temperature of the material measured by the condition of the atmosphere while laying, enters largely into the reason why such efforts have been unsuccessful. The necessity of having this valuable material put into durable and useful form, has led to the invention of a method by which such ends can be accomplished. This consists in crushing and heating limestone (which, when heated, has great affinity for bitumen), and, while heated, bringing it in contact with heated bitumen in proper proportions. This work is done by machinery specially adapted to the purpose, the mixing temperature being 252 deg. Fah. This mixture is then pressed into rectangular blocks of convenient size in a mould, under a pressure of about fifty tons, and is then treated in a water bath until cold and ready for use. This homogeneous material appears to possess all the necessary qualifications of a perfect pavement for any street, whether the traffic is heavy or light. It is in extensive public use in the United States, where, according to a number of certificates we have seen, it is giving every satisfaction. A piece of roadway, about 440 square yards in extent, has just been laid in Queen Victoria street, London, adjoining the Mansion House station of the District Railway, and was opened to traffic yesterday. The blocks weigh 22 lbs. each, but lighter and smaller ones are made for paving footways. The compressed bituminous pavement is flanked on one side by granite roadway pitching, and on the other by wood paving, so that an opportunity is afforded of testing the relative merits of the three systems.—*Iron*.

[From the London "Journal of Gas Lighting."]

The Calorific Power of Coal Gas.*

By Mr. F. W. Hartley.

[Read at the Eighteenth Annual Meeting of the British Association of Gas Managers, held at Birmingham.]

The calorific power of coal gas has often been brought under the attention of the Association at its meetings, and various statements of practical working results given; but no record is to be found in the proceedings of the manner in which the heating power is calculated from the composition; and although this information is to be obtained from scientific books, I have ventured to think that it ought to find a place in the records of our transactions, which form text books of reference, and the more especially so as of late years many startling assertions have been promulgated respecting the power of gas for heating purposes.

At the outset, however, we encounter a difficulty in the fact that very few complete analyses of coal gas have been published, the only ones which I can find and rely upon in relation to London gas being those of Dr. Frankland, made in 1851, and those made by Mr. T. S. Humpidge, of the College of Chemistry, in 1876. The analyses of these gentlemen, as given in the tables annexed, show that London gas differed in no very important degree in 1876 from its composition in 1851, except that from some cause the gas of 1876 contained an unduly large percentage of nitrogen.

Table I.

	Dr. Frankland. 1851.	Mr. Humpidge. 1876.
Hydrogen	48.70	49.33
Marsh gas	32.20	37.00
Condensable hydrocarbons (Cn Hm)	3.45	4.00
Carbonic oxide	7.92	4.97
Carbonic acid	0.30	0.00
Nitrogen	1.00	4.40
Oxygen	0.43	0.30
	100.00	100.00

Two methods have been practiced for calculating the heating power of coal gas from its composition—one, and an erroneous one, based upon the elementary composition of the combustible gases (that is, upon the respective weights of hydrogen and carbon contained in them); and the other, and correct method, based upon the actual volume or weight of the several combustible gases which are contained in coal gas. I say "correct" method, although it its quite open to doubt whether a mixture of combustible gases, such as hydrogen, marsh gas, olefines, and carbonic oxide, do not give a higher calorific effect than is represented by the sum which results from the addition of their several respective powers. In the next place, the hydrocarbons condensed by fuming sulphuric acid are several in number, but are estimated as equal only to olefiant in heating power. It is true that the volume of these is not great, and the volume of olefiant containing an equivalent of carbon to that of the condensable hydrocarbons is calculated from "carbon density."

The method of calculating the heat power of coal gas from the carbon and hydrogen is altogether wrong, because it leaves out of account the amount of heat which has already been expended in effecting the combination of the elements. The heating power of coals is of necessity, from want of knowledge of their proximate constitution, calculated in this erroneous way; that is, upon the basis of ultimate or elementary composition. Prof. Galloway says upon this point, "We are entirely ignorant as regards the density of carbon as it exists in coal. We cannot, therefore, know its proper calorific value; it is possible that its density is different in different varieties of coal. Still less do we know the proper calorific value of the hydrogen in coal; it can scarcely be the same when existing as the constituent of a solid body as when it exists in a free gaseous state. * * * From the experiments made on the calorific power of substances, it is known that the calorific power is, in general, less than the calorific power of its elements in their uncombined state. * * * As we neither know how the elements are combined nor their state of condensation in coal, the results obtained in calculating calorific intensity from its elementary composition can at best be only approximations to the truth." The hydrogen marsh gas (CH_4), carbonic oxide, and the illuminating gases (represented by the formula Cn Hm, as their composition is not found), are the combustibles; nitrogen, oxygen, carbonic acid, and water vapor being, under usual conditions, absorbers or abstractors of heat. Water vapor is not given in the analyses, but is of necessity always present in small proportion in coal gas as supplied for common use.

* The weights and gravities of the various gases referred to in this paper are based upon the old standard temperature and pressure—viz., 60° F. and 30 inch bar; these being most familiar to the majority of gas engineers

I deem it needful to make clear what is meant by "carbon density," and how the equivalent of olefiant is deduced from the result of an analysis of coal gas. A sample of gas, after being freed from carbonic acid and oxygen (the percentage volumes of these two gases being at the same time ascertained), is exploded with oxygen, when water and carbonic acid result. The volume of the latter is found by absorption. Another sample of the gas is freed especially from carbonic acid and oxygen. It is then treated with fuming sulphuric acid, which condenses the gases represented by Cn Hm. The percentage volume, or loss, is observed. The residual gas is then exploded with oxygen, and, as before, water and carbonic acid are produced; but the latter less in volume than with the first sample. Deducting the volume of carbonic acid resulting from the second experiment from the volume realized in the first, the difference, after due calculation for the volume of carbonic oxide, represents the carbonic acid due to the combustion of the hydrocarbon gases Cn Hm, and the "carbon density" of those gases. Thus, let A represent the CO_2 of the first experiment, B of the second, and C the volume of Cn Hm condensed by sulphuric acid, then A — B ÷ B = carbon density, or the quantity of CO_2 produced from a unit volume of the light-yielding gases.

In order to find the volume of olefiant which would contain a weight of carbon equal to that contained in a unit volume of Cn Hm, we have to take into account the fact that CO_2 contains in a given bulk—say one cubic foot—only half as much carbon as is contained in a cubic foot of olefiant which is C_2H_4. Hence the volume of CO_2 produced by the combustion of CnHm is multiplied by half the volume of the latter; or, what is the same thing, the percentage volume of Cn Hm found by condensation is multiplied by half the volume of CO_2 produced by combustion.

The average carbon density, or CO_2, produced from a unit volume of the condensed hydrocarbons in the samples of gases analyzed by Dr. Frankland was 4, and in the samples analyzed by Mr. Humpidge 3.5. Multiplying the percentage volumes by half these, we have—

Cn Hm 3.45 × 2.00 = 6.9 C_2H_4 (Frankland).
Cn Hm 4.00 × 1.75 = 7.0 C_2H_4 (Humpidge).

Substituting these figures for the Cn Hm in the previous tables, we have—

Table II.

	Frankland	Humpidge.
Hydrogen	48.70	49.33
Marsh gas	38.20	37.00
Olefiant	6.90	7.00
Carbonic oxide	7.92	4.97
Carbonic acid	0.30	0.00
Nitrogen	1.00	4.40
Oxygen	0.43	0.30
	103.45	103.00

The substitution of olefiant in place of the volume of condensable gases causes the total volumes to be represented by 103.45 and by 103 instead of 100; but as some if not all of the actual light-yielding gases must certainly have a higher calorific power than olefiant, we may fairly calculate the heating power of 100 volumes on the basis of the greater number. If any reduction were made, it should be subtracting in each case the excess volume from the hydrogen, and thus reduce hydrogen to 45.25 and 46.33 respectively, instead of 48.7 and 49.33.

A table (compiled by the late Dr. Letheby, from various trustworthy sources) of the calorific powers of gases and of some other substances, inclusive of that of coal gas itself, as determined by the late Mr. F. J. Evans, is given in the report of the proceedings of this Association for 1866. The powers for the gases in question are, as given in that table—

	Pounds of Water heated 1 deg. F. Per Cubic Foot.	Per Pound of Substance.
Hydrogen	329	62,030
Marsh gas	996	23,513
Olefiant	1,585	21,344
Carbonic oxide	320	4,325
Common coal gas	650	21,060
Cannel coal gas	760	20,140

Multiplying the percentages of the combustible gases in Table II. by the appropriate numbers, as above, we obtain in the result the calorific power due to 100 cubic feet:

	Frankland.	Calculated Power.	Humpidge.	Calculated Power.
H	48.70 × 329	= 16,022.3	49.33 × 329	= 16,229.6
CH_4	38.20 × 996	= 38,047.2	37.00 × 996	= 36,852.0
C_2H_4	6.90 × 1585	= 10,936.5	7.00 × 1585	= 11,095.0
CO	7.92 × 320	= 2,534.4	4.97 × 320	= 1,590.4
		67,540.4		65,767.0

or, in round numbers, 680 and 660 units per cubic foot.

To find the calorific power per pound of coal gas, we must find its specific gravity, and therefore must first find the density of the condensed gases. This can readily be done with tolerable exactness. One cubic foot of olefiant weighs 525.7179—say 526 grs., and by weight contains 24-28ths, or 6-7ths, of carbon. The respective weights of these elements must then be—Carbon, 450.86; hydrogen, 75.14; total, 526.00. 6.9 volumes, as per Table II., must contain—

Carbon	6.9 × 450.86 =	3,110.934
Hydrogen	6.9 × 75.14 =	518.446
		3,629.380

But the 3.45 cubic feet of CnHm in Table I. contained the same weight of carbon, or		3,110.934
The weight of hydrogen in the olefiant is	518.446 grs.	
But gives an excess volume of 3.45 cubic feet.		
One cubic foot of hydrogen weighs 37 grains; hence 3.45 × 37 =	127.650 grs.	
Weight of hydrogen in condensed gas		390.796
Weight of 3.45 cubic feet of condensed gases		3,501.730

This divided by 3.45 and then by 535.9 (weight of a cubic foot of dry air) gives the gravity as 1.894. In the same way the gravity of the condensed gases CnHm of Mr. Humpidge's analysis will be found to be 1.665.

We can now compute the weight of 100 cubic feet of the gases by multiplying the weight of each constituent gas by its gravity and by the weight of a cubic foot of air as in Table III., or by the weight of a cubic foot of each gas as in Table IV.

Table III.

	Frankland.	Grains.	Pounds.
H	48.70 × 0.0692 × 535.9	1,805.98	0.258
CH_4	38.20 × 0.559 × "	11,443.61	1.635
CnHm.	3.45 × 1.894 × "	3,501.73	0.500
CO	7.92 × 0.973 × "	4,129.74	0.590
CO_2	0.30 × 1.524 × "	245.00	0.035
N	1.00 × 0.972 × "	520.90	0.743
O	0.43 × 1.06 × "	244.26	0.035
Weight of 100 cubic feet		21,891.20	3.796
Weight of one cubic foot		218.912	

Weight of one cubic foot of air... 535.9 = .408 sp. gr.
32 cubic feet weigh 1 lb.

Table IV.

	Humpidge.	
H	49.33 × 37.08 (weight cubic feet)	1,829.16
CH_4	37.00 × 299.59 "	11,084.83
CnHm.	4.00 × 898.27 "	3,569.08
CO	4.97 × 521.53 "	2,592.40
CO_2	0.00 × 816.71 "	—
N	4.40 × 521.00 "	2,292.40
O	0.30 × 568.05 "	170.42
Weight of 100 cubic feet in grains		21,337.89
Weight of one cubic foot	213.38	

Weight of one cubic foot of air. 535.90 = .398 sp. gr.
33 cubic feet weigh 1 lb.

Multiplying 32 by 680, the calorific power of 1 lb. of Dr. Frankland's gas is shown to be 21,760 units; while 33 multiplied by 660 gives 21,780 units for Mr. Humpidge's gas.

According to the data furnished by the careful experiments of many scientists of eminence, such as Andrews, Favre and Silbermann, Regnault, Berthelot, and others, in melting ice and in raising water from about 32° F. to a few degrees above this temperature, by the combustion of the several gases which give heating power to coal gas, the foregoing calculations represent the highest calorific effects which are attainable with what we recognize as 15 or 16 candle gas. Whether, as before observed, a mixture of heat-yielding gases gives a higher result than that represented by the sum which results from the addition of their respective powers remains to be proved. I long since suspected such to be the fact, from certain experiences with a mixture of hydrogen and carbonic oxide, while certain engineering friends of mine entertain very strong convictions in favor of this proposition. For the present, however, we can only make our calculations upon the data accepted by the scientific world, and generally believed to be correct.

In the ordinary use of coal gas for heating water, its calorific power is much below that shown by calculation. Very much of the heat passing off to waste with the products of combustion and the nitrogen associated therewith, and more sometimes with the excess of air, which coming in contact with the vessels in which water is being made hot, becomes greatly raised in temperature, and carries away heat.

Let us suppose, first, that water is kept boiling; secondly, that only the quantity of air needful to burn the gas is supplied, and comes into contact with the vessel containing the water; and, thirdly, that the products pass off at no higher temperature than 212° F. Adding up the respective weights of hydrogen and carbon in the gas, as per Table IV., we find that we have the following results:

Table V.

	Hydrogen.		Carbon.
H	0.258		—
CH_4 4-16ths of 1.635	0.409	12-16ths of 1.635	1.226
Condensable, gases as per calculation	0.056		0.444
	0.723		1.670
Oxygen required to combine with H, 728 × 8.	5.784	Oxygen required to combine with C, 1.67 × 2.67	4.459
Water produced	6.507	CO_2 produced	6.129
		Add CO	0.300
		Plus 4-7ths of 0.3 to form CO_2.	0.176
		Carbonic acid	6.605

Thus the products from 100 cubic feet of such gas is 6.507 lbs. of water as steam, and 6.605 lbs. of carbonic acid. In the formation of steam 967 units of heat are rendered latent or insensible to the thermometer. Multiplying the pounds of steam produced (6.507) by 967, the product is 6392.27. The specific heat of carbonic acid is 0.2164; that is, 1 lb. of water requiring an amount of heat which we call *one* to raise it 1° in temperature, 1 lb. of carbonic acid requires less than one-fourth of such heat to raise it 1°. Multiplying the weight in pounds of CO_2 (6.605) by 212° F., and by 0.2164, the product is 303. The 10.419 lbs. of oxygen burned is, however, associated with 3.35 times its weight of nitrogen, or 34.9 lbs. Multiplying this by 212°, and by the specific heat of nitrogen (0.244), the product is 1805.3. Adding these three products together, we find that the total is 8500 units. Subtracting this from 68,000 (the unit power, in round numbers, of 100 cubic feet of gas), we have 5950 units per cubic foot of gas, or one cubic foot would give only 595 units of heat instead of 680. Practice, however, teaches us that at least twice the quantity of air needed for combustion is heated up in ordinary operations. This extra quantity would weigh 45.319, and this multiplied by 212° F. and by its specific heat (0.2379) gives 2286. Deducting this from the reduced power, 59,500, the remainder is 57,212, or 572 units per cubic foot.

In ordinary use we fail to realize this amount of heat by fully 200 units. In a long course of carefully conducted experiments, I took a Bunsen burner with four ¾-inch tubes as a standard, inasmuch as the results it gave were higher than those realized with any other. No doubt, because the heat was delivered exactly about the center of the vessel, and before escaping traversed the bottom more completely than the heat from broader burners. The indicated calorific powers after correction for barometric pressure and for the temperature—which correction it is quite as necessary to make in respect to gas used experimentally for heating as it is for gas when tested photometrically—ranged from 365 to 392; the water being raised from various temperatures between 40° and 60° up to 210° or 211°, and the average result being 382 units per cubic foot.

Under similar conditions, and using each burner in such manner and with such rate of consumption as was found to give the highest effect, a cluster of small fishtail burners gave results equal to 98 per cent. of the standard; an 8-tube Bunsen, 92 per cent.; Wallace's solid flame, 97 per cent.; a common one shilling article, which I think is called the "Egyptian," 91 per cent.; another known as the "Déposé," 83 per cent. One, which is much vaunted as excelling all others by its very modest constructor, gave 93 per cent.; and a larger one of the same kind 87 per cent., with the accompaniment of a detestable smell if the rate of consumption were unduly increased to a very trifling extent. Taking the average of the results realized with the best and with all the many other gas stove boilers tested, we have 360 units indicated as the power of the gas per cubic foot in raising water to 210° or 211° Fahr. If, as I believe, the real power of the gas employed was, on the average, 680 units, 320 units, or 47 per cent. of its heat were lost. The experiments made by myself during the past two years only confirm others which I have made at intervals during a number of years, and agree perfectly well with those made by Mr. Lewis Thompson with the gases of several companies in the years 1852–3; the average result of his experiments being 374 units per cubic foot.

It may be stated as a broad general fact, that the higher the temperature to which water is raised in an open vessel, by the aid of gas or other fuel,

the smaller will be the amount of heat utilized. Indeed, this fact holds good with the things called water-heaters, which can scarcely be regarded as open water vessels. With a water heater and water raised only a few degrees between 40° and 60°, I realized nearly 600 units in the water, but when the water was raised much higher the realized units sank to below 400. Another heater at its best gave only 390 units, while with a large cylindrical pot, charged with ten gallons of water, 370 units were secured on the same occasion. I have tried vessels with jackets of non-conducting material, but the difference produced was so insignifiant as to render it unadvisable to complicate burners for the use of the public by such additions.

When, some months since, I intimated to the Secretary that I was willing to provide a paper on this subject, I entertained the hope and expectation that I should be able to present at this meeting a simple calorimeter by which the heat power of combustible gas might be readily and easily ascertained; but, although I have not spared effort, I have not yet been successful. I hope, however, presently to accomplish the task, which is to me a most interesting one. I cannot but regret my inability on this occasion to place before you statements of the actual heat power of the same gas, as deduced from experiment, and from analysis and calculation.

What results ordinary London gas should produce in heating water, have been shown, so far as calculation goes. We have now to consider what weight and volume of air would be raised one degree Fahr. by a cubic foot of such gas.

Atmospheric air weighs, when perfectly dry, 535.9 grains per cubic foot; but under natural conditions, and at normal temperature and pressure (60° Fahr. and 30 in. barometer), a cubic foot contains 5.8 grains of water vapor, which is lighter than air, so that a cubic foot of such moist air weighs only 532.4 grains. As 7000 grains are equal to one pound in weight, it follows that the volume of one pound of moist air is 13.148—say 13.15 cubic feet. Dividing this number by the specific heat of air, 0.2379—say 0.238—the quotient is 55.25, which multiplied by 680, the calculated number of water units per cubic foot of gas, gives 37,570 cubic feet of air as the volume which would be raised one degree Fahr. This is on the supposition that the products of combustion mingle with, and form part of the volume of air heated, and without regard to the little differences in the specific heat of CO_2 and of nitrogen as compared with air. It is based also upon the assumption that the whole of the heat absorbed and rendered sensible in the water of combustion is given up as sensible heat, which might be the case if air were raised one degree from about 32°; but as it generally happens that the air is required to be raised a considerable number of degrees above that of the external atmosphere, the water vapor produced is insufficient to saturate the heated air. Such being the case, we lose the latent heat—at least, so it appears to me. Besides which the water vapor must be raised to the same temperature as the air, and its specific heat is 0.475; so that it requires just twice the heat which air does to raise a given weight through an equal number of degrees. The loss in water units for heat rendered latent in the water vapor was found to be 6392.27 per 100 feet of gas—say, 64 units per foot—which, multiplied by 55.25, gives the cubic feet of air to be deducted from 37,570, and leaves 34,034 cubic feet of air as the maximum volume which could, by any possibility, and according to the accepted data, be raised one degree Fahr. by the combustion of one cubic foot of London gas. With cannel gases, the proportion of hydrogen to the hydrocarbon gases is much less than in common coal gas. Hence less loss ensues in respect to heat rendered latent.

In conclusion, I may say that I have reasoned on lines which I think are correct, but which may be open to challenge at some points, and I cannot but again express my regret that I have been obliged to limit myself mainly to mere calculations, based upon analyses of coal gas. On some other occasion I hope to lay before you the results arrived at by precise experiments.

What I have said, however, is sufficient to show that in ordinary use we lose a tremenduous amount of heat, which loss we may hope will be reduced by improvements in boilers and boiling appliances, even as the loss has been very greatly reduced in gas-cooking ovens. In the meantime, do not let us be too severe on gas stove makers, whose instruments (some very cheap) for the most part, do as well, or nearly so, as burners of the very best construction, when used with great discretion and care.

Fatal Accident.

While George S. Smith, Henry Kimball, and a party of ladies were looking at the Brush electric light machines in the generating rooms on Ganson street, Buffalo, Smith commenced handling the machine, although warned not to do so by the manager, G. W. Chaffee. Smith left, but shortly after returned, suddenly leaned over the railing, and without warning grabbed the first and third Brush connections. Chaffee tried to save him, but he was instantly killed. His hands were badly burned, and his face wore a bluish, livid appearance. He was 28 years old.

Gas Matters in Nashville.

The Nashville (Tenn.) *American*, of July 15th, publishes the following report of the Committee of the Board of Aldermen to whom was referred the petition of the Rock City Gas Company, asking the privilege of laying their mains in the streets of that city:

REPORT.

On the 12th of May last, Messrs. J. F. Demoville, H. D. Fitch, William Litterer, W. H. Leekhart, John G. Greener, J. M. Dickinson and James S. Frazier, incorporators of the Rock City gas company, presented a petition to the Honorable Mayor and City Council of Nashville, asking the privilege of laying down pipes in the streets of the city through which to distribute a gas. Said company propose to manufacture and vend within the city limits, in accordance with the privileges and restrictions expressed in their charter from the State, and the bill now under consideration, introduced by councilman W. F. Glenn, on the 12th of May, and on the same evening, under a suspension of the rules, by the honorable board aforesaid passed three readings, this bill conferring such immense powers and privileges on the Rock City gas company, came to the honorable board of aldermen on the 24th of May, last, was passed on the first reading, and referred to a special committee of three for examination and report.

On the 7th of June following, alderman W. H. Hyronemus, of the Second ward, introduced the following proposition of the Nashville gas light company:

"*To the Honorable, the Mayor, Aldermen and Councilmen of Nashville:*

"Gentlemen—We, the gas light company, make the following proposition: We hereby agree to furnish to the city and citizens of Nashville, for the term of ten years, at $2.25 per one thousand cubic feet to citizens, and $2 to the city, with 25 cents per thousand discount for prompt payment within five days from the date of bill, which will net $2 to the citizens and $1.75 to the city; provided the city will give the Nashville gas light company exclusive and uninterrupted privilege to furnish gas to the city and citizens for the said term of ten years."

THOS. F. KENDRICK, *Secretary.* SAMUEL PRICHITT, *President.*

NASHVILLE, June 7th, 1881.

This proposition was referred by the board of Aldermen to the special committee of three, having under consideration the prayer of petitioners and the bill aforesaid.

The magnitude of the interest involved; the passage of the bill on three readings by the honorable board of common council, under a suspension of the rules, on the evening of its introduction; the high character of the citizens composing the new company, who seek the privilege, and the general anxiety of the community for cheaper gas, have induced your committee to bring to the consideration of this bill all the time, labor and research they have been enabled to command.

Desiring to obtain all the light possible on this important matter, both the Rock City gas company and the Nashville gas light company were notified of the first meeting of your committee, and each was requested to be present and furnish the committee with such explanations and facts as might elucidate the matters under examination.

On the first of June, in response to the notification, both of the companies aforesaid were represented before your committee, and the views of each were ably presented by astute counsel.

The Rock City gas company read a statement regarding the character of the works and the kind of gas they propose to manufacture and sell to the citizens of Nashville, and we append the same to this statement, marked exhibit "A." Also a statement by Prof. W. T. Lupton, relative to the works and gas manufactured at Gallatin, marked exhibit "13," together with his analysis of the Gallatin gas, marked exhibit "C."

The Nashville gas light company filed with your committee a "statement," by the same learned gentleman, concerning the quality of gas manufactured by said company in Nashville, which is also appended, marked exhibit "D."

Many statistics and interesting documents bearing on the matters under consideration were kindly furnished your committee by the respective parties in interest and from these we have been materially aided in this investigation.

Your committee are not learned in the science of chemistry or the various processes used in the manufacture of gas of a safe and good illuminative quality. It will not, therefore, be expected of the committee to enter upon the debated ground of the safety of petroleum or coal oil gases. They may be permitted, however, to observe that they can scarcely reconcile the wide conflict that exists in the opinion of eminent chemists on this important subject except it be on the theory of existing pecuniary interest. And we are reluctant also to believe that eminent scientists could be influenced in their conclusions by venal considerations however big the pay offered by the advocates of either gas for a favorable opinion.

The whole question has quite recently undergone a full and exhaustive examination by a special committee of the Boston board of Aldermen on an application by a new company for the privilege of laying gas mains to manufacture and vend gas in the city of Boston. Your committee are much indebted to the special committee of the Boston board for valuable information collected on this subject.

As shown by their report, there are substantially but three processes which have any considerable use.

First. Coal gas, which furnishes the only illuminating gas for all of the great cities of Europe, and of Boston and Philadelphia in this country.

Second. Petroleum or naphtha gas, in partial use in some cities in the United States.

Third. Water gas, in moderate use in half a-dozen processes in this country.

Taking this classification as correct, in connection with the statement of the directors of the new company, who have assured your committee that they do not intend to manufacture water gas, would classify the gas to be manufactured and sold by the Rock City gas company under the *second* head, of petroleum or naphtha gas.

Neither the application of the petitioners for the privilege of using the streets of the city in laying their gas mains and establishing their gas works nor the bill granting it anywhere refer to the kind of gas to be manufactured and vended by the new company. Under the bill, therefore, the said company would unquestionably have the right to manufacture and vend the poisonous water gas and thereby endanger the lives of our citizens. We regard it as the imperative duty of every municipal government to see that the gas distributed through its streets is safe and free from dangerous constituents. The weight of authority before your committee is overwhelmingly against the introduction of water gas under whatever name it may assume, as dangerous to life and property.

From the high character of the gentlemen composing the new company we do not believe their assurances would be violated during their control of the corporation, but gas stocks will change hands and soulless corporations will pass under the government of soulless men, desperately wicked and bent on the destruction of the people's rights, should it become necessary to advance their selfish ends. In view of these and other reasons that might be assigned, your committee oppose the passage of this bill, and all others of a similar kind, unless the city and citizens are amply secured against the introduction of a dangerous and unsafe gas.

Your committee think that learned chemists, however much they may differ in the safety of other gases, concur in the opinion that coal gas, such as is in use in our city at present, is the standard gas of the world—that it is safe, steady, reliable and comparatively free from the poisonous constituents that lurk so treacherously in the composition of gases of the second and third classifications.

The policy of allowing the introduction of new gas companies to compete with old established ones, or in other words of encouraging a plurality of gas companies in order to cheapen gas to municipalities and private consumers, has been carefully and with much interest considered by your committee. The question has agitated the municipalities of perhaps all the cities on this continent as well as in Europe, and has elicited discussions and experiments which have not failed to adduce all the facts and arguments within the grasp of the advocates of either theory. In addition, it has been considered and acted on by the National Legislature in its legislation for the District of Columbia. Nashville, therefore, could not attain to the full growth of true cityhood without passing through the same ordeal. It seems necessary for "purification" during the transition period.

Will the passage of this bill, with the grant of an almost perpetual right to a new corporation to tear up our narrow streets and pavements and interrupt public travel whenever its necessities or convenience might require it, have the effect to cheapen the price of gas to the city and private consumers?

After a pretty careful and general comparison of the prices paid for gas by other municipalities in the United States, the committee find that no city obtains its gas at so low or cheap a price as Nashville, in comparison with the cost of making it and the quantity sold, which are factors necessary to be considered in estimating prices. Few, indeed, North or South, obtain their gas so cheap as Nashville, even leaving out of account the difference in the amount sold and the cost of material used in its manufacture. This great advantage was secured to the city on March 18, 1850, by the insertion of a clause in its agreement with the Nashville gas light company, binding the latter to furnish the city with gas at one-half the price charged to private consumers.

By virtue of this agreement the city of Nashville obtains its gas for nothing—that is to say, the company pays more revenue into the city treasury by taxation than it obtains from the city by the sale to it of gas. In the course of its investigation the committee have found no parallel case in other cities. That is, the committee have failed, though it has diligently sought for it, to find any city government, outside of Nashville, with a contract so favorable for lighting its streets and municipal buildings.

As Legislators, we cannot, if we would, ignore the interests of the corporation in whose behalf we are commissioned and sworn to legislate faithfully and impartially. In the grant of rights, powers and privileges to other gas companies, we must guard with watchful fidelity the present unequalled contract with the Nashville gas light company.

To multiply, jeopardize or madly destroy it by inconsiderate legislation, superinduced, it may be, by partiality for esteemed citizens—prejudices, in many cases too just, against grinding monopolies, or from whatever other causes, would be to cover our legislation with the curses of our successors and the indignant denunciations of our constituency.

No citizen, we take it, with the interest of Nashville in view, would ask or expect the passage of the present bill unless its enactment would result in some considerable advantage to the city. And now having shown that the gas furnished by the Nashville gas light company is unquestionably safe, pure and free from danger, and that our municipal government obtains it at a price lower, in comparison to the amount of gas sold, and the cost of its manufacture, than any city on this continent whose gas statistics were obtainable by your committee, we come to the consideration of the last question of real importance to the citizens of Nashville, and that is, will the admission of a new company reduce the price of gas to the private consumers? And in this connection we will consider the proposition made by the Nashville gas light company to the Mayor and City Council at Nashville, and referred to the special committee having in charge the present bill.

It is manifest that the introduction of a new corporation for the manufacture of gas will bring into requisition additional capital upon which the consumers of gas must pay interest, while the quantity of gas required must remain the same. A competitive gas company will therefore, in a little while, increase the price of gas to the consumers in proportion to the increase in the capital employed in its manufacture.

[Here follows a lengthy extract from the Report of the Committeee of the Board of Aldermen of the city of Boston upon the petition of R. M. C. Graham, and others, to establish the manufacture of water gas in that city. This Report will be found in the JOURNAL, on page 249 of Volume XXVII., issue of Dec. 17, 1877.—ED.]

From a careful comparison of the prices paid for gas in those cities where competitive companies have been allowed under the syren promise, while seeking a foothold, of cheaper gas for the people, we find the statements of the eminent economist above quoted from, have been practically verified.

In some instances they have cheapened gas for a few months during the competitive war, but invariably ends in consolidation by a sale of one to the other, or by an agreement to divide territory and not compete therein, in both of which cases the gas consumers have had an increased capital upon which to pay interest, which has elevated rather than decreased the price of gas.

The great cities of Europe recognizing this theory as true, allow but one gas company. London has constituted the only exception of which your committee are aware, and for years the tendency in London has been to get rid of the existing plurality and consolidate into one gas company with a view to cheapen gas. From twelve gas companies she has reduced quite recently to three, and just in proportion to the reduction of gas companies has the price of gas decreased. In other words London is supplied with cheaper gas by her three companies than she was by her twelve.

In its investigation, your committee have found no instance where the admission of a competitive gas company has resulted in the permanent diminution of the price of gas.

We would cite the following cities in the United States, where the experiment of admitting competitive companies in order to reduce the price of gas has been fully tested, and with the result above stated: New York city, Brooklyn, N. Y., Providence, R. I., and New Orleans. Our sister city of Memphis, joined the last mentioned cities and a long list of others, not necessary here to enumerate, in an effort to obtain cheap gas through a competitive gas company. The result after a sharp, short war was a sell out by the new to the old gas company, an increase in the capital stock of the latter upon which the city government and consumers of gas in Memphis are now paying interest in the shape of high rates for gas.

Boston, Mass., on the contrary has persistently avoided the experiment of seeking for cheap gas by the admission of competitive companies, and her citizens are to-day enjoying cheaper gas than her sister cities above cited with their plurality of competitive gas companies. Your committee, therefore, are irresistibly led to think with John Stuart Mill in the statement above quoted, "that it is an unthrifty disposition of the public resources to have several sets of costly arrangements kept up for the purpose of rendering to the community one service when one set could perform the services equally well."

Your committee have very carefully considered the injury that would result necessarily to the city by the passage of the present bill, tearing up our

narrow streets and pavements, blasting through solid rock along every thoroughfare, alley and reservation within the city to lay gas pipes and mains, the interruption to public travel, and the consequent detriment to all business, necessary expenditures by the city in repairing injuries to streets when the process of laying mains by the new corporation shall have been completed and the settling of excavations fully set in, not to speak of the possibility of vexatious litigations for the alleged violation of vested rights when the war of the roses shall have been fully inaugurated.

The committee have sought in vain for results that would offset their great expenses, annoyances and disadvantages. They fail to discover the benefits that would accrue to any outside of the contractor and the parties immediately interested in the new gas scheme.

Your committee think that the Rock City gas company proposing to manufacture coal oil or naphtha gas for distribution through the city, would necessarily be at the mercy of the Standard Oil Company, the Southern wing of which, as your committee understand, is Chess, Carley & Co., of Louisville, Ky. This firm, in the opinion of your committee, could dictate any policy to the new company, and however averse to the resident incorporators might be its execution, still it must needs be carried out, for the reason that the oil from which the gas is manufactured could be withheld on a refusal to obey the behest of this greatest of oil monopolies in our land.

But "consolidation," "districting," and agreement not to compete, the increase of gas capital upon which interest must be paid, and a corresponding increase in the price of gas to the consumers constitutes the main ground of our objections to the passage of this bill.

It is always with more or less of regret that we oppose the granting of privileges to petitioning citizens whose pecuniary interests would thereby be advanced, but in this case our long acquaintance and high personal regard for the resident petitioners make a recommendation that their prayer be not granted extremely regretful.

But for the reasons above stated your committee recommend that the bill be rejected and the prayer of the petitioners be rejected.

The proposition of the Nashville gas light company is so clear and explicit, the opportunity for cheap gas to the private consumers so immediate and permanent, its terms so easily understood and comprehended in the light of the above report, that your committee have determined to return it without recommendation for acceptance or rejection, but leave it to the intelligent action of the individual members of this honorable board.

R. L. Caruthers, Jr.,
James McLaughlin,
C. F. Brown,
Committee.

July 12, 1881.

The Lighting of Industrial Establishments.

In an article on this subject in the *American Exchange and Review*, we find the following :

"If coal gas can be obtained from town or city companies at a reasonable price, there is no other gas and no plan so safe, with care to prevent leakage from pipes and joints, which, mingling with air, may make an explosive mixture. Many industrial establishments have been burned from this cause. A plan which might be very suitable for places where inflammable material is used, and where hands might be tempted to tamper with lights, would be to have small but numerous burners in rows of large gas pipe running about nine feet above the floor. Reflectors could be placed above, and though not surrounded by glass, these lights would be well removed from contact with materials and from interference of employes, while the light would be more evenly distributed through the rooms than by the usual method.

"In a mill where gaslights are all lighted at once by electricity, the danger of fire from illumination is much diminished ; but even here care must be used, because, as the gas is turned on to every burner at once, should the electric arrangement not work properly, there would be danger of a quantity of gas escaping into the rooms. There should also be outside of every mill or works using gas a valve, easy accessible, to close the main pipe, as many fires have been aggravated by the burning of gas from large pipes broken in the fire."

The London Gas Supply.

The total income from all sources of the four metropolitan gas companies last year amounted to just upon four millions sterling—or to be strictly correct, £3,993,298 17s. 6d.—of this sum £2,789,669 was received in respect of the sale of gas by meter, and £908,529 for residual products. Public lights and contracts figure for £221,272, and meter rents produced £57,995. The total expenditure of these companies during the same period, exclusive, of course, of outlay on account of capital, amounted to £2,699,613, showing a gross profit for the twelve months of £1,293,684. As compared with the returns for 1879, the above figures show an increase in the receipts of £66,530, but a diminution in the expenditure of no less than £64,078. In taking the gross profit made per ton of coals carbonized, we find that the Chartered Company comes first with 14s. 11d., the Commercial follows with 13s. 8d., then the South Metropolitan with 11s. 5d., and the London last, 8s. 11d. An analysis of the quantity of gas made per ton of coals carbonized shows that, while the Commercial Company made 10,476 feet, and the Chartered 10,346, the South Metropolitan Company produced only 9,803 feet. Readers of this journal scarcely need reminding that considerable difference of opinion exists among gas engineers as to the extent to which a large yield of gas per ton is an evidence of good and profitable working, and in illustration of the various circumstances which have to be taken into consideration, we need only point out that, while last year the South Metropolitan Company paid less per ton for coal than did any other company, in the matter of working expenses its outlay per ton was the smallest; in respect of the production of coke, it also occupies the first position.—*London Metropolitan.*

Pollution of the Passaic River.

The Newark Aqueduct Board recently made an inspection of the waters of the Passaic river, from which the Newark and Jersey City people draw their supply. The Jersey City Board of Works had been invited to accompany the excursionists, but not a member of the board was present. The purpose of the inspection was to ascertain the source and extent of the water's pollution. The water is certainly unfit to drink, and its odor is actually offensive as it pours from the faucets in the houses of consumers.

The trial of the Kingslands showed that one of the sources of pollution is the refuse and dyestuff poured into it from the mills that line the river, and the sewage and filth from them and from the cities fronting on the stream. The mill-owners still persist in emptying their refuse into the river, and the members of the Newark board are exerting themselves to the extent of their powers to put an end to the practice. The board notified those of the mill owners whom they saw that unless they built sinks for the collection of their sewage, and to prevent it mingling with the river water, they would be prosecuted. It is intimated that the Newark board will go before the next grand jury and seek the indictment of others of the mill owners than those who have already been prosecuted.

A new remedy suggested is to construct a sewerage system skirting Paterson and Passaic that will empty the sewage of the two cities below the Dundee Dam, and then to connect the water works of Jersey City and Newark with the waters above the dam ; but that plan will be an expensive one.—*Engineering News.*

Correspondence

[The Journal is not responsible for the opinions expressed by correspondents.]

Gas Purifying.

New York, August 3d, 1881.

To the Editor American Gas Light Journal :

"How much gas, per bushel of slacked lime, do you purify under your process ?"

This is a common inquiry, and one that ought to interest the entire gas fraternity. No one, probably, will deny that the quantity thus purified is a very fair test of the relative perfectness and purity of the crude gas as it issues from the retorts or ovens, and forms a material item in determining the relative values of the different modes under which illuminating gas is made.

The Citizens gas company, of Poughkeepsie, New York, has for more than six years made their gas solely and exclusively under the "Allen-Harris, or American Hydrocarbon Process," and I give a few facts as to the average quantity of gas per bushel of slacked lime purified by them.

From March 3d to 24th, 1881, the average was 84,944 feet of gas per bushel of lime, on over one and a-half millions feet purified.

From March 30th to May 4th, on 2,141,200 feet of gas purified, the average was 118,955 feet per bushel of lime.

From June 9th to July 11th, on 1,669,000 feet of gas purified, the average was 92,750 feet per bushel, and for the whole period, from March 3d to July 31st, 1881, they purified 8,308,700 feet with 126 bushels of slacked lime, being an average of 65,942 feet per bushel of lime, and which is a fair average under the above process.

Allow me, through the Journal, to inquire if results equal to, or at all approaching, the above, have ever been obtained under any other process since illuminating gas has been known? No washer is used—simply a condenser.

H. P. Allen.

THE AMERICAN
GAS LIGHT JOURNAL

A. M. CALLENDER & CO.,
PROPRIETORS.

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Manager—C. E. SANDERSON.

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Gas Stocks.

Quotations by G. W. Close Jr., Broker and Dealer in Gas Stocks.
(with W B Scott & Co.,)
34 PINE STREET, NEW YORK CITY.

AUGUST 16, 1881.

☞ All communciations will receive particular attention
☞ The following quotations are based on the par value of $100 per share.

	Capital.	Par.	Bid.	Asked
Gas Co.'s of N. Y. City.				
Central	$466,000	50	60	65
Harlem	1,800,000	50	84	86
" Bonds	170,000			103
Manhattan	4,000,000	50	210	215
Metropolitan	2,500,000	100	150	155x
" Scrip	1,000,000	..	105	109
Mutual	5,000,000	100	70	72
" Bonds, go'd.	900,000	1000	100	104
Municipal	1,500,000	100	175	180
" Bonds	750,000		106	110
New York	4,000,000	100	104	106
Northern	270,000	50	—	100
Gas Co's of Brooklyn.				
Brooklyn	2,000,000	25	125	130
Citizens	1,200,000	20	53	56
" S. F. Bonds.	320,000	1000	100	105
Fulton Municipal	1,500,000	100	70	75
Peoples	1,000,000	10	35	40
" Bonds	290,000	.	101	104
" "	250,000	...	70	75
Metropolitan	1,000,000	100	60	65
Nassau	1,000,000	25	62	64
" Ctfs.	700,000	1000	95	100
Williamsburgh	1,000,000	50	63	67
" Bonds		...	98	103
" Bonds	40,000	—	—	—
Richmond Co., S. I.	300,000	...	70	75
Out of Town Gas Companies.				
Buffalo Mutual, N.Y	750,000	100	72	76
" Bonds	200,000	1000	95	100
Citizens, Newark	918,000	50	85	90
" " Bds.	124,000	—	105	10
Chicago Gas Co., Ills			125	—
Cincinnati G. & C. Co.			178	180
Consolidated, Balt.			58	60
Bonds			107	—
East Boston, Mass		25	114	120
Hannibal, Mo	100,000	100	95	100
Hartford, Conn	700,000	25	140	144
Halifax N. S	400,000	40	148	150
Hamilton, Ontario	150.000	40	117½	
Jersey City	750,000	20	145	155
Jacksonville, Ill	120,000	50	100	...
Lewistown Maine	400,000	100	—	100
Laclede St Louis Mo	1,200,000	100	108	110
Montreal, Canada	2,000,000	100	153	154
New Haven, Conn		25	132	—
Oakland, Cal			32	33
Peoples, Jersey City		...	95	100
" " Bds.				5
Pittsfield, Mass			120	130
Rochester, N. Y.		50	70	80
" Citizens		100	30	35
Woonsocket, R. I.	150,000	100	80	...
Wilmington, Del.		50	174	...
Yonkers		50	30	32
Rondout & Kingston			75	80
St. Louis Missouri	600 000	50	250	254
San Francisco Gas-Co., S. Fr'isco Cal.			68	69
Toledo, Ohio			95	97
Troy, Citizens	600,000	100	—	—
Washington, D. C.	1,500,000	20	190	200
" Scrip	500,000	20	150	160

Sold at auction; 233 shares Metropolitan, at 150¼; 528 Manhattan, at 210½-¾.

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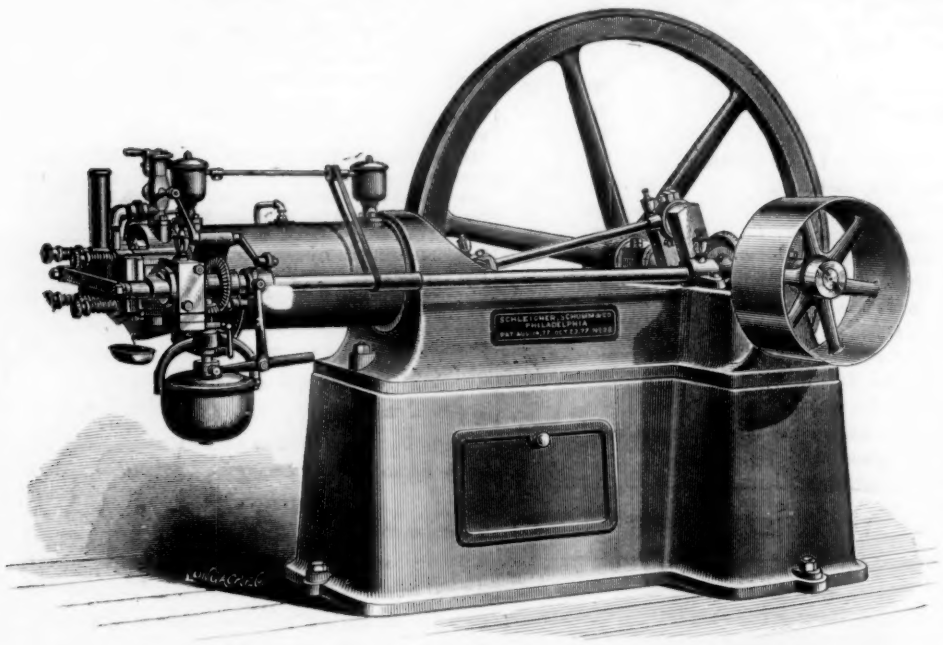

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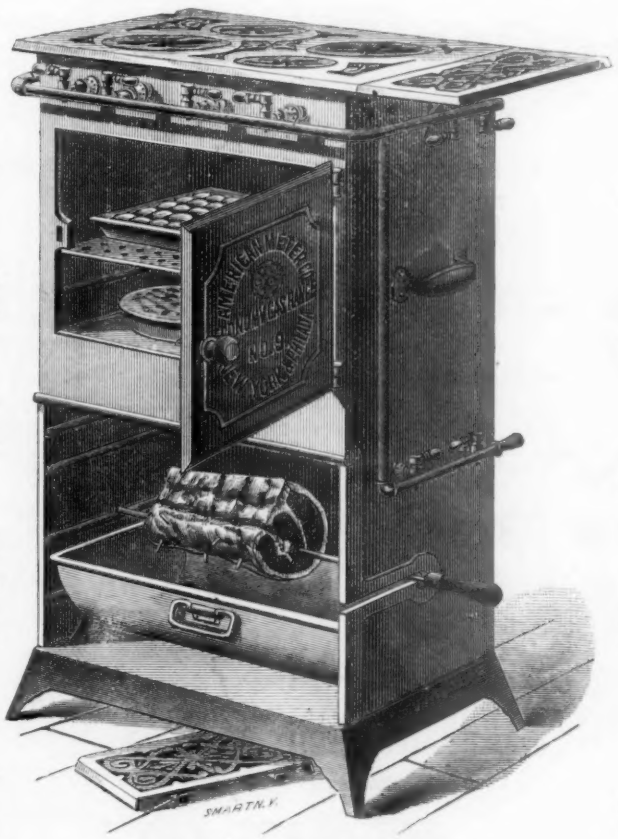

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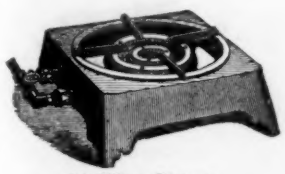

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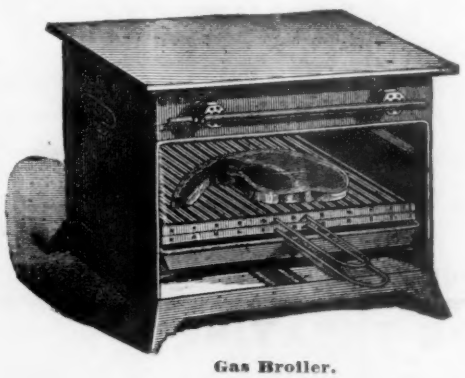

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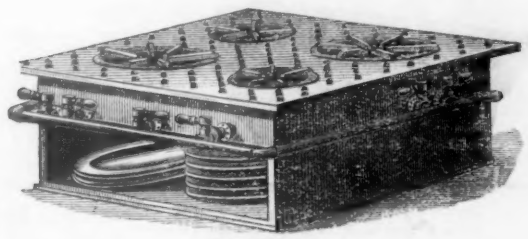

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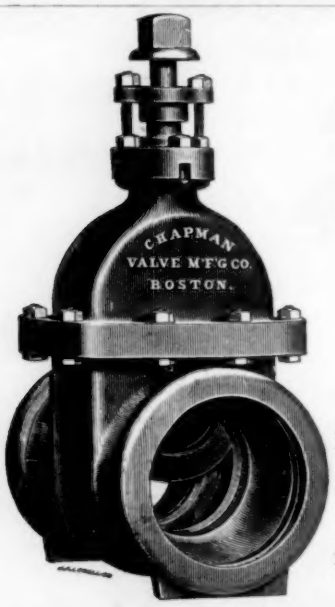

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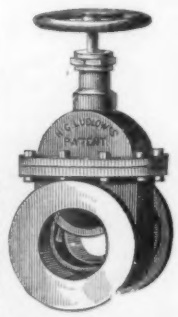

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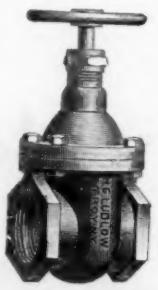

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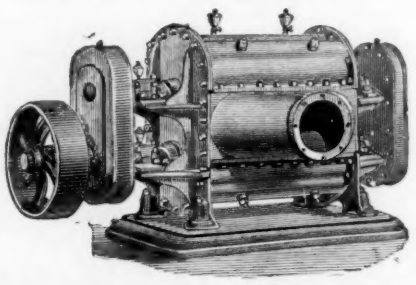

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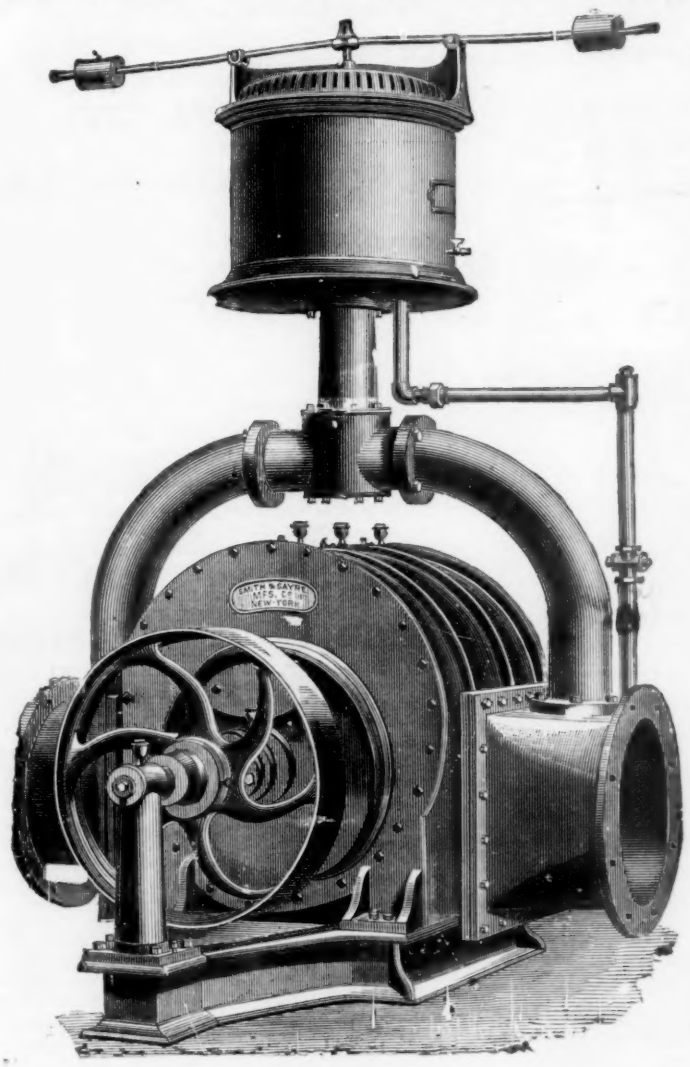

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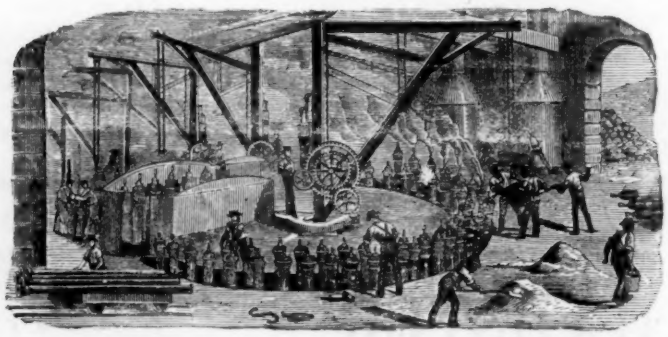

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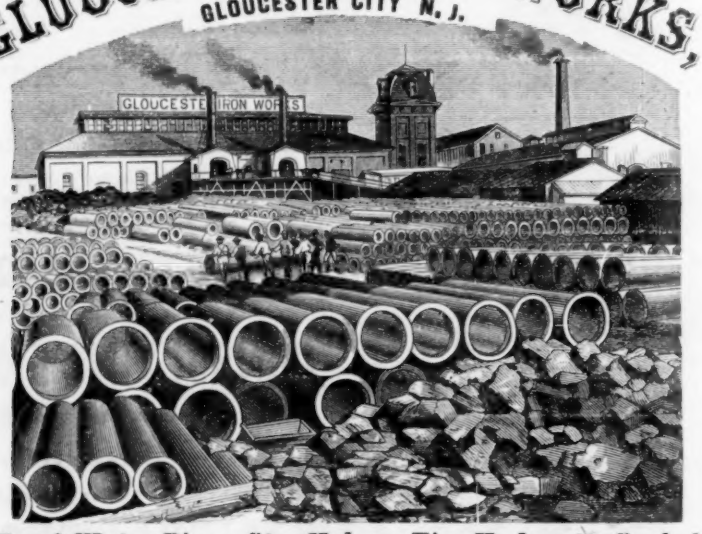

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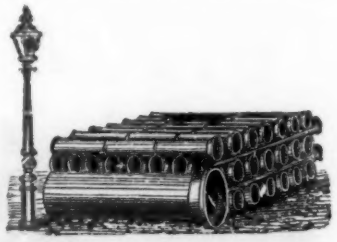

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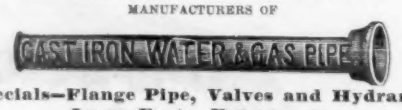

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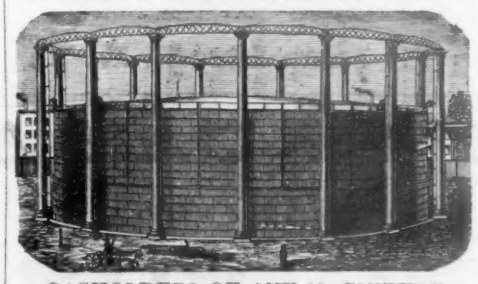

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Best dry coals shipped from Locust Point, wharves, and prompt attention given to orders for chartering of vessels.

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Wharves Locust Point, } Baltimore.
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Among the consumers of Despard Coal, we name: Manhattan Gas Light Company, New York; Metropolitan Gas Light Company, New York; Jersey City Gas Light Company, N. J.; Washington Gas Light Company; Portland Gas Light Company, Maine

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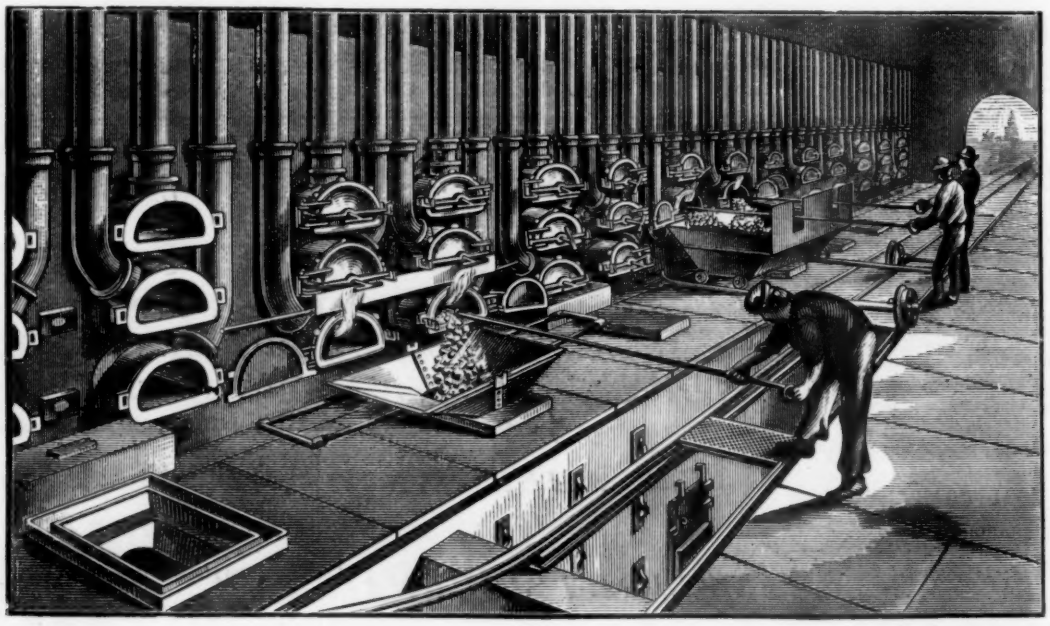

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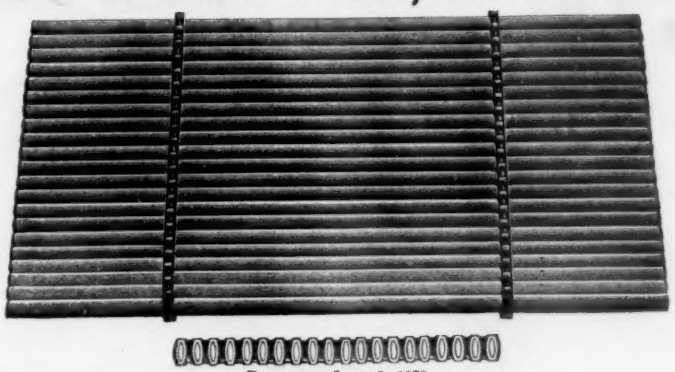

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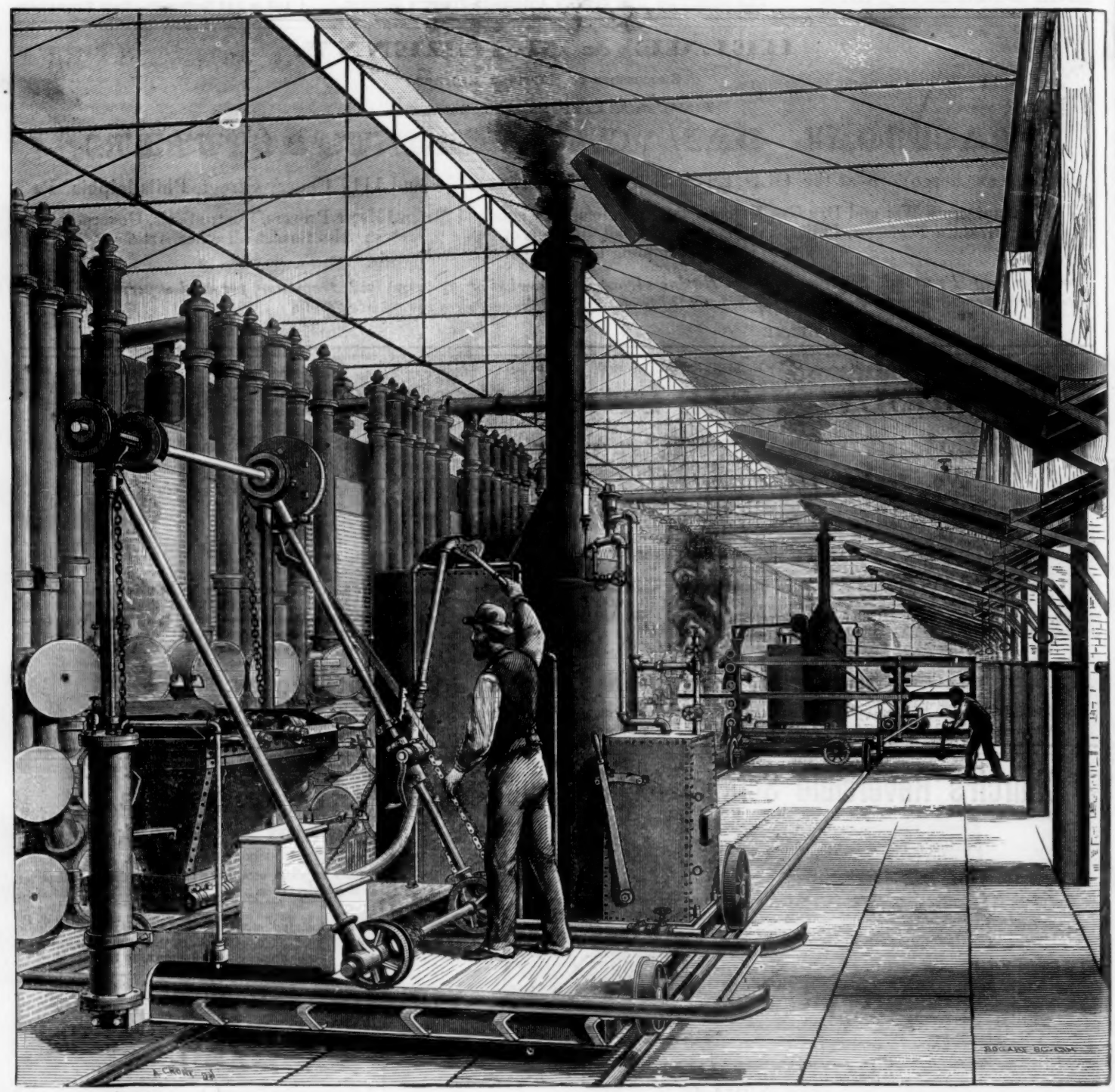

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